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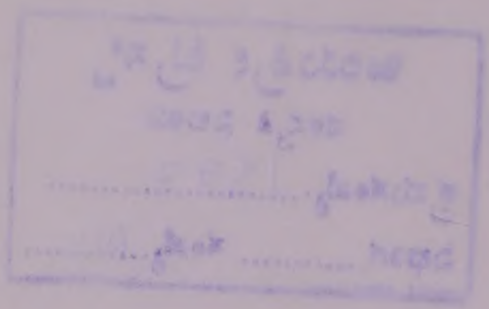
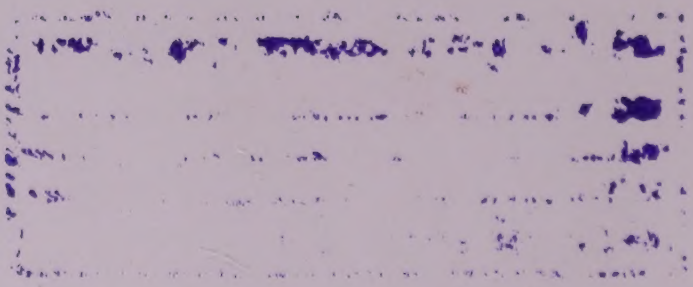


OF SCIENCE AND SCIENTISTS



Popular Science

OF SCIENCE AND SCIENTISTS

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Foreword

As one grows old, one recalls with pleasure incidents and events not only in one's life, 'the Roses of December', but in that of others as well. They are mostly, if not always, intended for entertainment. But Prof. Kothare's 'anecdotes' have a purpose far beyond that of raising a smile. Their object is to instruct and edify. Prof. Kothare himself says that they should form part of a value-oriented education system. Viewed this way, they are analogous to the fable and the parable. While these two are mostly imaginary, anecdotes are factual though one cannot vouch for the truth of each one of them especially when they are based on hearsay. I am glad to learn that even in his class-room lectures (as testified by Dr Homi Sethna, former Chairman of the Atomic Energy Commission), Prof. Kothare used to explain the theories with appropriate anecdotes. As a student of physics myself, I can understand how far anecdotes about scientists go in relieving the monotony of 'definition, experiment and problems'.

I am a great believer in scientific progress and appreciate its varied gifts to humanity. If today the world is described as a 'global village', it is mainly due to the revolutionary changes brought about in transport and communications through the technological application of scientific discoveries. The success of the Green Revolution in India in the sixties was the result of the adoption of a package of measures, the most important of which was technology in the form of high-yielding varieties of seed, fertilisers and pesticides in a regime of water control and

management. Scientific education is the sine qua non of general progress and a scientific temper is indispensable for sustaining that progress. But, at the same time, the progress of man *within*, the spiritual dimension of man, should not be ignored. "Science without religion is lame," said Albert Einstein.

Swami Vivekananda declared: "I do not mean that those who want to search after truth through external nature are wrong, nor that those who want to search after truth through internal nature are higher. These two are the two modes of procedure. Both of them must live; both of them must be studied; and in the end we shall find that they meet."

We are apt to look upon scientists as staunch monogamists wedded to science alone. They are as human as most of us, with strengths and weaknesses, failings and foibles which are common to us all. But they have their eccentricities as well as noble traits like humility and sympathy. For instance, Henry Cavendish (1731-1810) "the richest of all the learned and the most learned of all the rich", was a misogynist. Madame Curie (1867-1934), whose father could not pay for her education, agreed to work as governess till her elder sister completed her medical education. Einstein could tell the mother of a child, who had sought his help in doing some homework, that "I have learned more from the conversation with the child than she did from me." Charles Darwin (1809-1882), after a meeting with Prime Minister Gladstone, could say with humility, "He talked to me as if he were an ordinary person like myself." Thomas Huxley (1825-1895), a self-proclaimed agnostic, did confess that "love has opened up to me a view of the sanctity of human nature." Apart from these anecdotes, Prof. Kothare has enhanced the value of his book by essays entitled 'Science, Scientist and Truth' and 'Humour, Humility and Humanism' among others. If these essays give the different facets of science, the anecdotes reveal the personality of the scientists.

Prof. Kothare (87) is a veteran educationist with six decades of experience as a teacher, research worker and administrator. His text-books on organic and inorganic chemistry have been used by generations of students.

Prof. Kothare has been intimately connected with the Bharatiya Vidya Bhavan, especially in the activities of the Bhavan's 'Ancient Insights and Modern Discoveries' project. The project aims at correlating the ancient thought enshrined in the *Vedas* with the fruits of modern scientific research.

I whole-heartedly commend this book by Prof. Kothare, Prof. S.M. Parekh, Dr M.P. Navalkar and Prof. Sudhanshu Palsule to students, teachers and laymen interested in science, scientists and progress through science.

C. SUBRAMANIAM
President
Bharatiya Vidya Bhavan

Bombay
5 Jan. 1994

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To the National Book Trust, India for bearing with us when delays occurred at different stages before printing.

We are deeply indebted to Mr C. Subramaniam for his learned foreword. Mr Subramaniam was, till recently, Governor of Maharashtra and is the president of the Bharatiya Vidya Bhavan.

As Minister for Agriculture in the Government of India, in the sixties, he took bold decisions that ultimately led to the Green Revolution that made the country self-sufficient in foodgrains. Nobel laureate, Dr Norman Borlaug, publicly acknowledged that the Green Revolution became a reality because of the strategy adopted by the government in popularising new varieties of seeds. Dr Borlaug went to the extent of saying that the Nobel Prize should have gone to Mr Subramaniam.

It is a matter of special satisfaction to us that Mr Subramaniam is a graduate in physics.

Preamble

The three primary questions that scientists direct towards their field of investigation are 'what', 'how' and 'why'. 'What' stands for observational questioning, 'how' admits operational questioning and 'why' finally, brings out explanatory questioning.

WHAT: Observational questioning requires clarification of two aspects: scientists and the field of science. The field of science comprises different spheres—astrosphere, atmosphere, lithosphere, hydrosphere and biosphere. These spheres are not isolated or sealed from one another, but are inter-permeative and interacting. The happenings in one profoundly affect the actions in the rest. In each sphere there are certain facts and phenomena, firstly, for observation and explanation, and secondly, for control and exploitation. These observational questioning spheres have been classified by Dr Karl Popper into three worlds: World 1—the ordinary physical world, or the world of physical state; World 2—the mental world or the world of mental state which may be considered as psychosphere; and World 3—the world of actual or possible objects of thought—the world of concepts, ideas, theories, theorems, arguments and explanations, i.e. of all the faculties of the mind or the precognitive abilities. The second world of Karl Popper includes the 'self' or the scientist and his cognitive abilities for questioning. The third world is the sphere of thoughts and ideas which is an exo-cognitive condition. Isaac Newton recognised the third world (when asked how he had made such great discoveries in his life, his reply was that he had the privilege to stand on

the shoulders of intellectual giants).

The second facet of 'what' is the scientist himself—a scientist with a physical body which is the gateway to physical information. Binet has called the body 'a chest of tools'. In the process of evolution, *Homo erectus* (first man) became *Homo sapiens* (modern man) and reached a state of *Homo faber* (man the maker) and in this evolutionary process he acquired the mental cognitive abilities (thinking power) and the 'structurally opposable thumb'. (This phrase commonly used by eminent sociologists refers to the structural change in the process of evolution which gives the human hand the ability to construct or use it for purposes of experimental work. Animals do not have the 'opposable thumb' or the thumb which opposes the other fingers). These evolutionary changes were responsible for man's scientific and technological progress. With his cognitive abilities he could formulate hypotheses using the observational data of information. This called for adoption of an experimental approach either to verify or to falsify the formulated hypotheses.

Another question pertains to identifying the rich investigating fields that the scientist chooses for himself. Broadly it is the synergetic action of cognitive abilities and affective attitudes. This concept can be brought out clearly from Einstein's essay on 'My Plans for the Future' which he wrote as a schoolboy. To quote relevant parts of this essay: "I imagine myself becoming a professor in particular branches of natural sciences choosing the theoretical parts of them. The reason for this is though...the individual disposition for abstract and mathematical thought, the lack of fantasy and of practical talent." At the zenith of his scientific achievements he admitted, "I am not cut for a tandem (bicycle meant for two)." This statement brings out the shift from personal choice to collective obligation represented by team work in scientific investigations. The team work is today represented by the establishment of R&D (research and development)

centres in industries and political involvement in mission-oriented research work as seen in America's Manhattan Project for development of the atomic bomb.

Team-oriented research has been possible due primarily to the phenomenal growth of scientific disciplines and secondly, to sophisticated instrumentation needed in research. The 'sealing wax and strings' aspect of laboratories in the historical past has been replaced by the 'push-button' instrumentation in the present laboratories and which is contributing towards 'big team science'. Scientific investigation today has lost its primary function of 'open book publication' and shifted to patent-oriented publication.

The mission-oriented research work like the Manhattan Project imposes on such work the stigma of secrecy. Dr Oppenheimer, who successfully conducted the Manhattan Project, was forbidden access to State research work. In the late 1940s when he as a member of the Manhattan Project, was made to appear before the Senate Armed Services Committee and asked, "Doctor, is there any defence against such a nuclear weapon?" his reply was in the affirmative.

He was then asked, "What is that, Doctor?"

Dr Oppenheimer replied, "Peace."

J. Rostand, the Kalinga prize-winner of 1959, has observed in his prize-winning oration: "Laboratores must open right on the street. All men have the right to receive the truth and the truth has the right to reach all men."

HOW: After settling 'observational questioning', scientists enter into 'operational questioning' by asking 'how' of the problem. In olden times, man's curiosity with his cognitive abilities helped the unaided eye to explore the sky and a few segments of the astrosphere. Thus began the initial study of astronomy by the Babylonians and Egyptians and subsequently by the Greeks. The cognitive abilities for this study involved mathematical concepts such as Euclid's geometry. The

plate on the entry-door of Plato's academy carried the following notice for eligibility to admission: 'Nobody should enter the academy who does not know geometry'. However, working with 'opposable thumb' during experimental work was considered demeaning for acquiring elitist status. Experimentation was greatly frowned upon for it was seen to be unworthy of the lofty ideals of Greek standards. The story goes that during a scientific discussion, in one of the academies in Greece, a young man was asked how many teeth were there in a horse's mouth. The young man promptly secured a horse and proceeded to count its teeth. Both he and the horse were unceremoniously thrown out of the academy.

The unaided-eye observation, which was confined to the astrosphere, benefitted immensely when investigations were pursued through the methodology of experimentation. It is said that science came from the heavens to the earth on the inclined plane of Galileo. An experiment is an interaction of the physiological and psychological apparatus with the physical apparatus being utilised for the study of a phenomenon. Physiological and psychological apparatus stand for the scientist while the physical aspect represents the apparatus—tools, instruments, machines, models and computers. Leonardo da Vinci has rightly said, "Theory is the *General* and experiments are *soldiers*."

Physical aids must serve three important functions:

- assist and extend the observer's senses;
- hold the unrequired variable constant; and
- convert a phenomenon not detectable by senses into perception.

The first aspect of physical aids has great value when one of the senses, like the eye, has limitations in observation. These limitations have been overcome by developing different types of microscopes and highly accurate telescopes. The microscope helps to bring into focus minute organisms. Discovered by Levwenvoch, this instrument

has not only the 'magnification' but also the 'resolving' power. However, even this advanced instrument failed to bring viruses into the vision. Technologists then developed the electron microscope which proved beneficial in the study of viruses and the diseases caused by them. The observable distance with the unaided eye had to be extended beyond its field of vision with the help of telescopes. This instrument underwent technological developments to result finally in the discovery of the radio telescope. The sense of touch, as everyone knows, became a measurable factor with the discovery of a simple instrument, the clinical thermometer. The heart-beats of a patient which were earlier examined by the medical man by putting his ear on the chest of the patient (very embarrassing in case of a female patient), can now be conveniently checked with the stethoscope.

In the second aspect of physical aids, scientists while studying the different facets of a phenomenon basically want to study only one of them so as to detect any change in the phenomenon. The study of gases is done with such apparatus particularly meant for measuring temperature and how it is related to pressure and volume of gas.

In the third aspect of physical aids, apparatus and machines are the prerequisites for studying radioactive materials. The Geiger-counter brings into focus the decay of radioactive material otherwise not possible with the naked eye.

Such precious assistance given by various sophisticated physical aids in the investigation of phenomena made Dr Broglie comment, "There is one special form of the mechanical art in which the machine becomes the servant of the intellectual curiosity; the form is the experimental technique which supplies the scientist the necessary instruments to study nature and discover its laws."

WHY: This question is an important facet of scientific adventure. 'Why' is explanatory questioning with three

different aspects of scientific adventures. The first questioning is the summation of the results of the experimental work and the conclusions drawn from the same. The second facet is the conclusion so reached and how much status it has as a scientific truth. The third aspect is whether such scientific truth stands justified both in the macro and micro fields of scientific investigations. The famous nuclear scientist Dr Oho R. Frisch has written the first chapter of *Encyclopaedia of Ignorance* and has entitled it 'WHY'. He gives the different aspects of 'why' by asking the following questions:

"Why did Jones break his leg?"

"Because his tibia hit the kerb," says the surgeon.

"Because some fool dropped a banana skin on the road," says Mrs Jones.

"Because he never looks where he goes," says a colleague.

"Because he subconsciously wanted a holiday," says a psychiatrist.

These 'whys' the scientist (the medical man) can justify through X-ray examination; the psychiatrist justifies by the nascent science of psychology; while the two others have explained it more by the heart than by the head. The explanations of 'why' reveal both exposed and hidden variables.

Dr Oho R. Frisch, for a single event, cites five different 'whys' involving the head and the heart. Scientific investigation after 'what' and 'how' raises the last crucial question—'why'—that needs answering on different levels of the scientific structure. This can be illustrated by the experimental work of the great scientist Isaac Newton. When he passed a ray of light through a prism, it emerged on the other side in seven different colours (VIBGYOR). The first 'why' goes back to what happened; the second 'why' is a link with 'how' and answer to the second question realises the phenomenon 'truthful' to reality. Newton answered the second question on the basis of

gravitational theory and justified it on the basis of the corpuscular nature of light. Huygens performing the same experiment answered the last 'why' of Newton's on the wave theory of light and this brought in clash of head and heart. Newton expressed his anguish and blamed his own prudence for publishing it. He received substantive support on the 'thought experiment' of Einstein, a genius of a scientist, who said that if a ray of light has to pass by the side of a large astral body, it will get attracted and bent. He explained that the light rays are 'photons'. Einstein's thought experiment on the bending of light was proved right to the exact decimal point by Eddington in his observation of the eclipse. Einstein said, in justification to his theory, "Now that my theory of relativity has been proved true, Germany will claim me as a German and France will declare that I am a citizen of the world. Had my theory proved false, France would have said that I am a German and Germany would have declared that I am a Jew." The head and the heart fused together to explain the final 'why' of the rays of light through the corpuscle and wave theory of light as proved by the great scientist Sir W.H. Bragg, who said, "On Mondays, Wednesdays and Fridays we use a wave theory of light and on the other three days, the corpuscle theory of light."

It may be necessary here to cite another example which stands as a 'breakthrough' in science, in the same way as above. Breakthroughs are turning points which upset the previous concepts in science and have been called 'paradigm-breaking' by Dr T.S. Kuhn. The 'breakthrough' phenomenon not only justifies the new experimental concept but also contributes towards further progress of scientific advances and helps to bridge the different disciplines in scientific investigations. Such events in the scientific world include Rutherford's discovery of the nucleus of the atomic structure and Roentgen's discovery of X-rays. The result of Rutherford's experiment on the bombardment of gold foil with beams of particles,

drew from him the following observation, "It was quite the most incredible event that ever happened to me in my life. It was almost as incredible as if you had fired a 15-inch shell at a piece of tissue paper and it came back and hit you." The conclusions of these observations established the central factor of the atomic structure and Rutherford was awarded the Nobel Prize in 1908, in chemistry, for 'Investigations into Disintegration of Elements'. Acknowledging the felicitation for the award from Otto Hahn (who split the atom), Rutherford wrote: "I much appreciate your kind congratulations and wishes on the award...I must confess it was very unexpected and I am very startled at my metamorphosis into a chemist." The breakthrough not only altered the concept of the atom but also changed the physicist into a chemist.

A breakthrough brings about a complete change in the previously held concept of the phenomenon. Secondly, it brings about new directions and helpful assistance in other disciplines. X-ray stands as the best example of both the factors of breakthrough. The discovery of X-ray by Roentgen stands as an example of *serendipity*, i.e. discovering something other than what you are experimenting for, as is the case of the scientist who was working on the passage of electricity through rarefied gases. During this work his wife stepped into the laboratory and accidentally put her hand on an unexposed photographic plate and, thereby for the first time, X-ray photo of the bones of her hand was recorded. The discovery of this unique phenomenon of Roentgen rays popularly known as *X-rays*, was a breakthrough of the main experiment that he was conducting. This discovery brought about stupendous advances in biochemistry, particularly molecular biochemistry where the discovery of the structure of the DNA (the Double Helix) by Watson and Crick secured for them the Nobel Prize in medicine. Another important aspect of X-ray is its use in medicine which allows surgeons and physicians to explore the innermost

part of the human body without surgically opening it.

The conclusions of experimental work done in a scientist's own laboratory sometimes need public approval or a seal of approval by established scientists in the field or publication in a reputed journal to claim priority of the justified conclusions of the experiment. For the first type of confirmation (public), two experimental works may be cited. When Von Guericke's experimental proof of pressure of atmosphere on human body did not find public approval, he had to perform a spectacular experiment in front of a large assemblage. He selected two huge Magdeburg hemispheres that could be joined together after air had been evacuated from them. Two teams of eight horses harnessed to each hemisphere could not separate them but could do so easily when the stop-cork was opened, to allow air to enter inside. Louis Pasteur, on the other hand, had to prove publicly the protective action of his vaccine against the virulent culture anthrax. The experimental proof needed two groups of animals comprising sheep, goats and cows. One group was given his protective vaccine against anthrax while the other remained unprotected. The observational period of experiment was nearly three weeks in the presence of visiting groups of farmers till the final result of the protective value of Pasteur's vaccine was proved.

In France, scientific discovery had to be justified before a team of experts appointed by the Science Academy, as was the case in Moissan's discovery of fluorine or in Pasteur's separation of salts of tartaric acid. In Moissan's case, when he announced isolation of fluorine, the Science Academy appointed an observation panel consisting of his own professor Fremy, who had himself been unable to isolate the gas. On the first occasion Moissan failed to isolate the gas before the committee. After adjusting the defective aspects Moissan succeeded in showing the collection of the gas. Fremy immediately expressed his surprise by saying, "A professor is always happy when

he sees one of his students proceed further and higher than himself."

The second instance was in the separation of two identical salts of tartaric acid which differed in their structure. When separated by a polarometer, one salt solution turned the light to the left and that of the second turned to the right. When this experiment was performed before the distinguished panel of scientists, Biot, the seniormost scientist, expressed his excitement at this breakthrough, "My dear child, I have so loved the sciences throughout my life, it makes my heart leap with joy."

The third mode of justification is to publish one's experimental work in a reputed and appropriate scientific journal to claim the priority of the results expressed in one's writing. Failure to choose a reputed journal for one's publication may delay recognition in the scientific world. An American scientist J. Willard Gibbs put forth his 'phase rule' to explain the thermodynamical principle in chemistry, but remained unrecognised due to its publication in a small unknown American journal. After nearly twenty years, German scientists with their gift of recognising the genius of other nations put this 'phase rule' before the scientific world after collecting material on it from the dusty volumes of the journal. Gibbs was called to be honoured by German scientists which made Gibbs remark, "Had this honour come to me twenty years earlier, how much greater work I would have done." This remains the *cri de coeur* of the scientist for the failure of recognition of his scientific work.

With proliferation of research work in various laboratories of different nations, it is essential to get it published immediately in order to claim the priority for the work. This is fully illustrated in the case of the scientific work on the structure of DNA by Crick and Watson. Crick and Watson's total work on DNA consisted of two research papers published in *Nature*. The first one was published in April 1953 confirming their assumption of

the structure on the basis of the evidence of X-ray. The second paper was published in the May 1953 issue of *Nature*, where they claimed that the molecule had the capacity for its own self-replication. They hesitated in fully mentioning the importance of the structure of DNA for genetic inheritance and referred to it in a single sentence in their first publication. This showed that their caution was due to the meticulous protection of their right on the basic and the most important outcome mentioned in the second paper. The two papers claimed for them the Nobel Prize in 1962.

Dr Otto R. Frisch says that 'why' has different levels of not only explaining the 'incident' (John's fracture) but also different levels of cognitive pursuits commonly referred to as 'disciplines'. In biology, 'why' is more successfully explained on the basis of *teleology* (development is based on the purpose for which it is meant) or is justified by natural evolution. In chemistry, 'why' is justified on the basis of the physical structure of the molecules and explains the reactions on thermodynamical laws of enthalpy and entropy. However, in the case of physics, if the study of sub-atomic studies fails, it leads to the principles of indeterminacy or probability. This reasoning for 'why' in principle was opposed by Einstein. He said, "God does not play dice with the world," and added a very significant sentence, "it seems hard to sneak a look at God's cards...it is something that I cannot believe for a single moment." Thus failure in ascertaining the 'why' is due to the fact that the instruments used for sub-microscopic events play a role which prevents the maintenance of variables constant. Frisch called them the 'hidden variables'.

ANECDOTES FROM THE LIVES OF SCIENTISTS

AGASSIZ, JEAN LOUIS
Naturalist (1807-1873)

This Swiss-American naturalist, geologist and teacher made significant contributions to *ichthyology* (the study of fish forms) and knowledge about ice glaciers. After attending the academy at Lausanne, Agassiz took his doctor of philosophy degree from Erlangen, and his doctor of medicine from Munich. His first major scientific work was a detailed study of a large collection of fishes from the Brazilian Amazon. This work was published in 1829 when Agassiz was only twenty-two years old. In 1833, he published his epoch-making work, *Recherches sur les*

Poissons Fossiles, in which he named nearly 1,000 fossil fishes. Turning his attention to other extinct animals apart from fishes, Agassiz published between 1839-1840 two more volumes. He then began a new line of study—that of the movements and effects of glaciers in Switzerland. In 1846, he left for the United States and lectured at various American universities and finally accepted a professorship of zoology at Harvard, where he subsequently developed a comprehensive museum of research in zoology. With the publication of his book, *Le Systeme Glaciare,* Agassiz became a reputed and popular figure at a very young age.

He was once out travelling with some friends and stopped at a place for refreshments. An elderly traveller was also passing by and, hearing the name Agassiz mentioned, came over to the young man who had been addressed by that name. "Pardon me, but are you the son of the celebrated Professor Agassiz of Neuchatel?"

Agassiz merely smiled and before he could say anything, one of his friends remarked, "You are standing before Professor Agassiz himself."

The traveller moved away with an apology murmuring to himself, "Such a modest young body for such a wise old head!"

His book on ichthyology had won Agassiz the coveted Wollaston Prize. He went to England to receive it and confronted some scholars who were rather sceptical about his work. They had just acquired a fossil so old that it outdated all other available specimens of fish. Taking advantage of the fact that even Agassiz had not described the fish in his books as he had never seen the fossil, they started testing the authoritativeness of his knowledge by asking him to describe the type of fish that might be found in a certain low geological stratum. The Swiss naturalist went to the blackboard, and after discussing a few preliminary points, drew a sketch of the 'hypothetical' fish. The fossil-specimen that the team had acquired

was then brought in for comparison. The sketch bore an unusual resemblance to the actual specimen. A thunderous applause followed and one of the spectators remarked, "As if by miracle, this man has unearthed the very plans of God!"

Agassiz had become a household name in Neuchatel. His passion for science and his works became a legend. Once a well-known geologist Leopold von Buch visited him and remarked jocularly, "At Neuchatel, every time I knock at the doors of Agassiz, I am afraid lest he should take me for a new species."

Once Agassiz had declined to deliver a public lecture on account of the inroads his previous lectures had made upon his research. The gentleman, who had been deputed to secure the invitation, continued to press Agassiz to accept, assuring him that the society would pay liberally for his services.

"This is no inducement for me," replied Agassiz angrily. "I cannot afford to waste my time in making money."

Agassiz's method of teaching was through personal discussions rather than imparting information. He discouraged the use of books except in detailed research. Among his favourite expressions were: "If you study nature in books, when you go outdoors, you cannot find her"; "it's not text-books we want, but students"; "the book of nature is always open"; "strive to interpret what really exists".

In spite of the strong premonition that his end was approaching near, Agassiz kept himself active and preoccupied with the construction of a summer school on the remote island of Penikese, off Buzzard's Bay, where teachers of nature could undertake scientific investigations under his guidance. The island was eighteen miles away from the nearest coast and the school building was an old abandoned barn. A few days before the class was expected to arrive, he reached the island to find the work

on the old barn incomplete. Undaunted, Agassiz called the carpenters together. With all the religious fervour of a priest delivering a sermon, he said, "There is no personal gain involved in this school. There is no money to be made. Its only purpose is to promote education. We are confronted with an emergency. Since tomorrow is Sunday, it's up to you to decide whether you want to work or rest."

"We will work," replied the carpenters in unison. And so, when the boat from New Bedford arrived with its party of students and teachers, the school was ready. On the wharf, as they disembarked, there stood the lone figure of the old professor. He gathered them around him and uttered a silent prayer. For the next few weeks, he was to have the greatest influence on science teaching in America. When he died a few months later, the school closed for ever.

ALDUS SALAM (Servant of Peace)
Physicist

Aldus Salam was awarded the Nobel Prize for physics in 1979. He believed that the awards that he won were Allah's gifts and hence must be given back to Allah. In keeping with his noble religious thoughts, all the money that he received from different awards (Atoms for Peace Prize L 30,000, Nobel Prize $ 66,000, Barcelona Prize $ 100,000 and Edinburgh Prize L 5,000) was not credited to his personal account but given away to different charitable and educational institutions.

He was former Director of International Centre for Theoretical Physics (ICTP) established at Trieste.

AL-RAZI, MUHAMMAD
Clinical physician (865-925)

Reputed to be the greatest clinical physician of Islam, Muhammad Ibn Zakariya Al-Razi earned the title of the

Arabic Galen (after the legendary Greek physician Galen), and was referred to as the "most brilliant genius of the Middle Ages" for his phenomenal achievements in the field of medicine. Al-Razi received his medical training in Baghdad, but later returned to Persia, the land of his origin, to set up a hospital in Tehran.

Apart from being an extremely gifted physician, Al-Razi was a free and radical thinker who believed that man was fundamentally a rational being and that divinity lay in this very faculty of rationality. This perspective, he said, allowed him to be an ethical and religious physician, who could care very deeply for his patients, whether they were rich or poor and whatever was their social status.

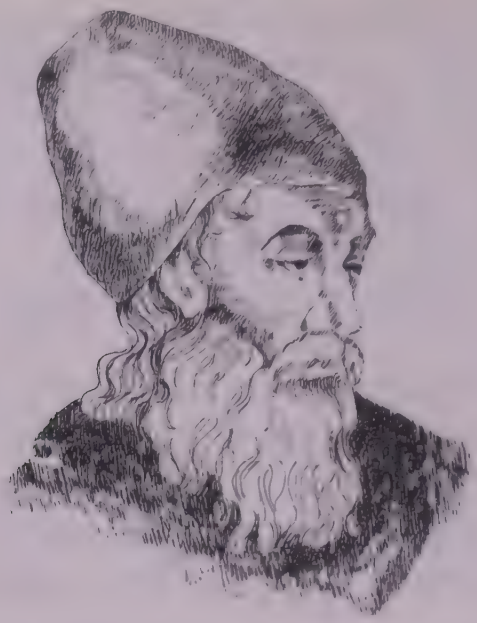
His unconventional views on religion, however, did not endear him to the dominant beliefs of that time. Later writers condemned him for blasphemy because he openly spoke of the superiority of reason over revelation. Due to his radical views, most of Al-Razi's scholarly works were either destroyed or relegated to oblivion.

Once, enraged by his blatantly unorthodox views, the Emir of Bukhara ordered that Al-Razi be struck on the head with his own book on medicine until either the book tore or his head broke. At the end of the beating, Al-Razi lost his eyesight completely. Ironically, later critics attributed his blindness to divine retribution. As a result of this humiliation, Al-Razi lost all interest in living further, and when an occulist suggested remedial eye surgery, he replied, "I have seen enough of this world and I do not cherish the hope of seeing more of it." He died shortly thereafter.

ARCHIMEDES

Mathematician and scientist (287 B.C.-212 B.C.)

Greek mathematician, physicist and inventor, who made numerous original contributions in mathematics and



geometry, was also responsible for certain areas of statics, hydrostatics and mathematical physics. His inventions were mainly mechanical devices that were used in war and later in peace. Archimedes studied in Alexandria, the centre of scientific studies at that time and was a student of the Euclideans. His first invention was a 'screw', useful for raising water from the Nile to irrigate fields. The geometrical basis for this invention was the helix and the cylinder.

Archimedes is most well known for the utterance "Eureka! Eureka!" (I have found it! I have found it!) which was supposedly his exclamation at having discovered that the king's crown was a fake, since he found that the specific gravity of the material of the crown did not tally with that of pure gold. The ingenuity of his discovery lay in the event when lying in a bath-tub he had insight into what is today known as the Archimedes principle. This principle states that a body immersed in a fluid is buoyed up by a force equal to the weight of the displaced fluid. The ratio of the weight of a substance to the weight of water it displaced when immersed in it is therefore a constant and is known as the specific gravity of the material. So great was his joy at this discovery that Archimedes ran out into the streets of Syracuse, totally

unaware of his state of undress!

King Hieron had doubts about Archimedes' claim that he could lift great weights with ease, using such absurdly simple contraptions as pulleys. Archimedes is said to have told the King, "Give me a point of support and I shall move the world." He constructed a multiple pulley, attaching one end of the rope that ran over it to a heavily laden ship. He handed the other end of the rope to the King and asked him to pull it gently. The King pulled it and to his great astonishment, the ship was lifted out of the water!

His well-known writings include *Floating Bodies; The Sand Reckoner; Measurement of the Circle, Sphere and Cylinder; Method* and *Book of Lemmas*. In 1906, a lost manuscript found by a Danish scholar Jørn Heiberg carried Archimedes' attempt at explaining his scientific method.

King Hieron asked Archimedes to devise new weapons when the Romans were threatening to attack his native city Syracuse. On discovering that a Roman fleet had set sail under Marcellus, the feared Roman Commander, Archimedes turned to the King and said, "I believe I can destroy the fleet."

"By what means?" asked the King.

"By means of burning mirrors," replied Archimedes.

The King shook his head sadly, thinking that Archimedes was either inebriated or was losing his faculties. Yet when the time came, Archimedes kept his word. He trained a battery of specially constructed concave mirrors that reflected the blazing rays of the sun directly onto the ships. Sure enough, the fleet was destroyed!

The legendary Marcellus, on seeing the devastation Archimedes had wrought upon his fleet, is said to have exclaimed, "Let us stop fighting this geometrical monster, who uses our ships like cups to ladle water from the sea, and has whipped our most efficient engines and driven them off in disgrace, and with the uncanny jugglery of his mind, has outrivalled the exploits of the hundred-

handed giants of mythology." It seems that the Roman soldiers became so petrified of Archimedes that whenever they saw a bit of rope or a stick of timber projecting over a wall, they cried, "Here he comes!"

So great was the respect that Marcellus had for his adversary that when the Romans finally succeeded in attacking Syracuse, he is said to have commanded, "Let no one dare lay a violent hand upon Archimedes. This man shall be our personal guest."

But the command was disobeyed. Archimedes was sitting quietly on the edge of a market place, drawing a circle on the sand, absorbed in mathematics, when a drunken Roman soldier rushed up to him with a sword. Archimedes quietly said, "Before you kill me, my friend, pray let me finish my circle."

But the soldier paid no heed and plunged his sword into his body. "Ah well!" Archimedes sighed just before dying, "They have taken away my body, but I shall take away my mind."

ARRHENIUS, SVANTE AUGUST
Physical chemist (1859-1927)

Arrhenius, the Swedish Nobel laureate of 1903, was awarded the prize for his theory of electrolytic disassociation in chemistry. His doctoral thesis, that he submitted at the Uppsala University in 1884, contained the same work. Ironically, his thesis was awarded the lowest passing grade as it was too revolutionary for the examiners!

In 1889, Arrhenius discovered the remarkable nature that chemical reactions display with rise in temperature. The equation that he wrote was found to be perfectly applicable to not only ordinary chemical reaction rates, but biological rates as well. In the later years of his life, Arrhenius worked on a remarkable hypothesis that life on earth may have originated on other planets. His suggestion was that the first earthly organisms may have

been viable spores driven through space by the pressure of starlight.

Arrhenius served as Director of the Nobel Institute of Physical Chemistry in Stockholm from 1905 till he died. His last book was *Chemistry in Modern Life.*

Arrhenius, while putting down his revolutionary 'Disassociation Theory', was forced to follow the model of the more antiquated theories of substances and solutions of the time. Obliged to make his work look more presentable, he infused into it some degree of verbosity, which made the dissertation rather weighty and overpowering. Years later, after being awarded a third-class degree, he was given the Nobel Prize for the same work. It was said that the only person who was impressed by the 'weight' of his thoughts was the janitor who had to carry the thesis to the referees!

ARYABHATTA

Atronomer (*b.* A.D. 476)

Aryabhatta, the legendary Indian astronomer, is credited with the discovery of the rotation of the earth. He lived at a time when interest in astronomy was at its peak in India, and he provided a well-formulated basis for future work through his famous astronomical treatise.

Ancient Vedic chants filled the air. In A.D. 499, at twelve noon on March 21, a twenty-three year old astronomer sprinkled holy water on his parchment and quill. He gazed at the sun overhead, and while chanting holy verses, wrote down the first letters of a treatise, in the presence of other priests chanting in the background. Although much of what Aryabhatta wrote was based on thoroughly well-formulated observation and deduction, the moving spirit behind the young man's insights into astronomy was decidedly spiritual. This young astronomer spent the next months writing, with very little respite, the legendary epic *Aryabhatiya*. Much before the

concept of the earth as a spherical object rotating around its own axis gained prominence in the West, Aryabhatta had stated it so in his treatise.

BACON, ROGER
Philosopher and scientist (1214-1292)

Bacon was the English philosopher and holder of the somewhat over-generalised title 'Father of Modern Science'. Bacon's significant contribution to the philosophy of science was his explanation about the role of experience and experiment in confirming or refuting speculative hypotheses. Bacon was a firm believer in the practical value of scientific speculation and insisted that the criterion for the use of scientific knowledge should be part of a unifying ethical system. He is also credited with the discovery of gunpowder, eyeglasses, and other important inventions, although there are no clear records that can testify this. His early studies were in the Faculty of Arts at Oxford and in early 1240 he went to Paris to teach at the Arts Faculty of University of Paris. It was in Paris, years later, that he turned his attention to providing a religious dimension to science through the influence of Aristotle.

What is not so commonly known is that during his study of the laws of optics, Roger Bacon came tantalisingly close to the principle of the telescope. In his writings can be seen the following paragraph: "I believe I have come upon certain laws whereby a child might appear to be a giant and a man a mountain...Thus a small army might appear very large...So also we might cause the sun, the moon and the stars in appearance to descend here below and similarly to appear above the heads of our enemies..."

Bacon's life took a different turn in 1252, when he joined the Franciscan Order, although he was extremely unhappy in it since the very beginning. However, he carried on working on optics and the phenomenon of

natural light and the rainbow. However due to his differences with the authorities, he was transferred at short notice to Paris in 1257. There he was even more miserable as he lacked money and other amenities. His irascible temperament became worse, and people studiously avoided him. Undaunted however, he managed to write the *Opus Majus*, which is filled with moral fervour, a characteristic of Bacon's writings.

From the tiny window of the prison cell to which he was confined, Bacon would look out at the stars in the night and dream of the day when his discoveries would be accepted and lenses fashioned to bring the celestial objects closer to the earth. A few days before his death, he gathered his students around him and said, "I believe that humanity shall accept as an axiom for its conduct, the principle for which I have laid down my life—the right to investigate. It is the credo of free men—this opportunity to try, this privilege to err, this courage to experiment anew. We scientists of the human spirit shall experiment, experiment, ever experiment. Through centuries of trial and error, through agonies of research...let us experiment with laws and customs, with money systems and governments, until we chart the one true course—until we find the majesty of our proper orbit as the planets above have theirs...and then at last we shall all move together in the harmony of our spheres under the great impulse of a single creation—one unity, one system, one design."

Later chronicles reveal that he was imprisoned when he returned to England in 1272, owing to a blasphemous work that he had published at that time. Due to his quest for scientific truth, which he understood to be perfectly compatible with religious feeling, Roger Bacon incurred the wrath of the clergy. He was subsequently imprisoned and put in solitary confinement for fourteen years. When he was finally set free, just before his death, his body was a skeleton, but not his spirit. "The true man of

science," wrote Bacon, "neither receives wealth nor seeks it...If he frequented kings and princes he would easily find those who would bestow on him honours and wealth. But that would hinder him from pursuing the great experiments in which he delights...In his pursuit of knowledge, the philosopher can remove even the walls of his cell to the outermost limits of the world..."

BAEYER, JOHANN FRIEDRICH ADOLF VON
Organic chemist (1835-1917)

Baeyer was a German Nobel laureate who was awarded the prize in 1905 "in recognition of his services in the development of organic chemistry and the chemical industry through his work on organic dyes and hydroaromatic combinations." His first achievement was the preparation of barbuturic acid, the base for what are commonly referred to as sleeping pills. By 1880, he had become well known for his work on indigo dye and other synthetic organic compounds, which were soon patented and marketed industrially. With his student William Perkin Jr., he formulated the famous 'Baeyer's Strain Theory', which indicates why rings of five or six carbon atoms are

the most common. Among his other notable students were Freidrich Thiele, F. Schlenk, Heinrich Otto Wieland, Kurt Meyer, Emil Fischer and Otto Fischer.

Baeyer studied chemistry at Heidelberg University with the esteemed Robert Bunsen, whose emphasis on the importance of physics in chemical training and research are well known. Baeyer had the good fortune of having another renowned teacher, none other than the founder of the benzene structure, Freidrich August Kekule. However, later in life, when Baeyer was asked whom he ascribed his learning to, he surprised all and angered some by saying that he held no respect for his formal education. Baeyer always claimed that he was self-taught and that was the only true education.

One of the great characteristics of Baeyer's research work was his ability to use extremely simple apparatus. His credo was that good research seldom needed complicated gadgetry and simple 'home-made' apparatus could suffice. One day, in deference to this credo, some students brought a mechanical stirrer into the laboratory. When Baeyer came to work the next day, he spotted the gadget immediately and was immediately apprehensive and suspicious about its merits. He then asked one of his students to call Frau Baeyer to come and see the contraption. Her first remark, on seeing it was, "What a lovely idea for making mayonnaise!" which probably left the scientist even more confused than ever.

BANTING. SIR FREDRICK GRANT
Medical scientist (1891-1941)

The Canadian physician, who shared the Nobel Prize in 1923, made an extraordinary breakthrough in medicinal research by extracting the insulin hormone from the pancreas. This immediately made it possible to prolong the lives of the victims of diabetes mellitus. Prior to this, the high level of glucose accumulation in the bloodstream

meant certain death. Banting was, incidentally the first Canadian to be awarded the Nobel Prize.

Banting's achievement in extracting the insulin hormone was all the more remarkable because all previous efforts to isolate the hormone had failed. This is because once the pancreas is removed, its digestive enzymes soon break down the insulin molecules. What Banting and his assistant Best did was to tie off the pancreatic ducts of several dogs for a period of seven weeks, after which the pancreas shrivelled up and were functionless as digestive organs. The source of the insulin hormone, called the 'islets of Langherans', however remained intact and a solution was extracted from these cells. This was how the first insulin was isolated!

Banting was forty-nine when the Second World War broke out. He promptly reported at a hospital base in Ottawa. "I'm too old to fight, Sir," he said to the Colonel in charge. "But, I'd like to join up with your medical unit at the lowest ranking you can give me." He was given the rank of Captain and he protested violently saying that he would prefer to be a private. When he was raised to the rank of Major, he protested even more and refused to accept the promotion. After all other persuasive tactics had failed, he was told that if he didn't accept the position he would be promoted even further to a Colonel. At which point, Banting conceded defeat and condescendingly accepted the rank of a Major, saying, "I suppose a man can try his best even in an exalted post."

'A stubborn man'—these were the words that best described Banting. For instance, he was lying in hospital, after being injured badly in the battle of Cambrai. His arm had been shot and there was no chance of saving it. "We must operate immediately," said the Army doctor to Banting.

"You're not going to take my arm away from me," replied Banting. "Not if I can help it."

"We must amputate, my boy. Otherwise we may

not be able to save your life," the Army doctor insisted.

"Oh no, not my arm. I'll risk the chance of dying." And with these words, Banting turned on his side. He risked his chance and lived. Six years later, he received the Nobel Prize for medicine.

Banting and his trusted assistant Best did their work on insulin in the laboratory of John J.R. Macleod, a professor of physiology at the University of Toronto. Although Macleod was from the laboratory and did not participate in the work, the 1923 Nobel Prize in physiology and medicine was awarded jointly to Banting and Macleod. Banting was furious that Macleod and not Best had received a share of the award. Immediately upon accepting the award, he sent half of it to his assistant, with a telegram that read: "You are with me in my share, always."

In February 1941, Banting took off in a bomber for London. The plane ran into a squadron of German fighter planes and was shot down. There was no other hope but to bail out. Banting, seeing that the other two had no possibility of doing so, stubbornly refused to leave the doomed aircraft. The plane finally crashed into a frozen lake and came to rest five feet deep in snow. The radio operator was dead, and the pilot though badly injured stumbled over to the cabin to see Banting lying quietly, his eyes wide open and blood streaming profusely from a huge gash in his head. His lips began moving and the pilot quickly produced a pencil to take down what the famous man had to say. But it was impossible to understand what the doctor was saying. Soon it was nightfall and Banting began to lapse into bouts of unconsciousness. The pilot, realising that he must get help, left the plane and went out into the wilderness. When he returned, he found Banting lying on the snow five feet away from the plane. Before dying, he had somehow managed to struggle out of the wreckage and drifted out into the open.

BERTHELOT, MARCELIN
Chemist (1827-1907)

One of France's most distinguished chemists in the 19th century, Berthelot's major contribution was to show that chemical phenomena are not governed by any special laws but are explicable in terms of the general laws of mechanics that are in operation throughout the universe. Berthelot is credited with the invention of the terms 'exothermic' and 'endothermic'. Berthelot became the professor of organic chemistry at the *Ecole Supoerieure de Pharmacie* in 1859, and a member of the Academy of Medicine.

The story goes that the Berthelot and the Breguet families had been friendly for years but Marcelin had not dared to openly look at the beautiful Breguet daughter, Sophie, until one day, an accident brought them into collision on the Pont-Neuf. She was crossing the long bridge in front of Berthelot and making her way with difficulty in the teeth of a strong wind, when a sudden gust caught her skirt and Tuscan hat and blew her straight into his arms. A week later, Berthelot found himself married!

On the occasion of the public ceremony to honour his seventy-fifth year, Berthelot once again insisted on the humanising spirit of science. "It is not for the satis-

faction of our private vanity that the world today pays homage to the man of science. It is because it knows that the man of science really worthy of the name, consecrates his life disinterestedly to the great work of our age—the amelioration of the lot of all, the rich, the poor, the happy and the suffering. I know not if I have completely fulfilled the noble ideal, but at least it has brought me strength to have made this the aim that has directed my life."

Reminisced his fellow-chemist and friend Dixon: "Berthelot was kindness itself. We were taken home and entertained by Madam Berthelot, whose silver hair heightened the saint-like beauty of her face. Berthelot was full of fire and quick replies. When Williamson rallied him on the rapidity with which his memoirs appeared, Berthelot replied, 'Ah! You English are too cautious, too frightened of committing yourselves—what is worth doing is worth publishing!' It was perhaps characteristic of him that an hour before he had given me the opposite and better advice!"

Berthelot once returned home to find his wife nearing her end and they both knew that death was near. "What will become of him when I am no longer there," were the last words she spoke to her daughter.

Berthelot was alone with his wife when she died. He then called his children into the room, kissed the lifeless form, walked into the next room and threw himself upon a couch. Hearing him sigh, his son ran to him and seized his hand, but Berthelot was already dead. Dixon commented: "It was the cry of the heart that cannot survive separation."

BERZELIUS, BARON JONS JAKOB
Chemist (1779-1848)

Regarded as the organiser of the science of chemistry, Berzelius is credited with the discovery of selenium and

thorium, and with the isolation of silicon, molybdenum and several other elements. He also evolved his dualistic electrolytic theory, which stated for the first time that all compounds are made up of negatively and positively charged compounds. Earlier in his career, Berzelius gave his attention to combining weights of elements and is said to have determined the combined weights of forty-three elements by analysing with his own hands some 2,000 different compounds. Considering that the laboratory facilities of the time were extremely limited, it goes to his credit that some of his results, when converted to modern formula weights, are amazingly accurate.

Berzelius was a colleague of the famous trio of the time: Joseph Louis Gay-Lussac, John Dalton and Sir Humphrey Davy. The quality of his experimental work and the remarkable consistency of his theories made him one of the great scientists of all time.

Berzelius did not marry until late in life. He wrote in a letter: "Yes, my dear Woehler, I have now been a benedict for six weeks. I have learned to know a side of life of which I formerly had a false conception or none at all." The bride was more than thirty years younger than Berzelius, but they had a blissful married life. On his wedding day, as Berzelius entered his bride's home, he was handed a letter from the King of Sweden, Charles Jean, with instructions that it was to be read aloud to the guests. It announced that Berzelius was to be given the dignity and title of 'Baron', in recognition of his eminent services to Sweden. It was a little more than ten years before his death, Berzelius was awarded the title of 'Baron'.

Berzelius was the most respected doyen of research workers in chemistry. Sefstrom and Wohler, both had worked in his laboratory. Sefstrom discovered a new element 'vanadium', while Wohler had missed this discovery in his own work. However, apart from many other contributions in chemistry, he had succeeded in synthesis of urea which constituted a breakthrough in chemis-

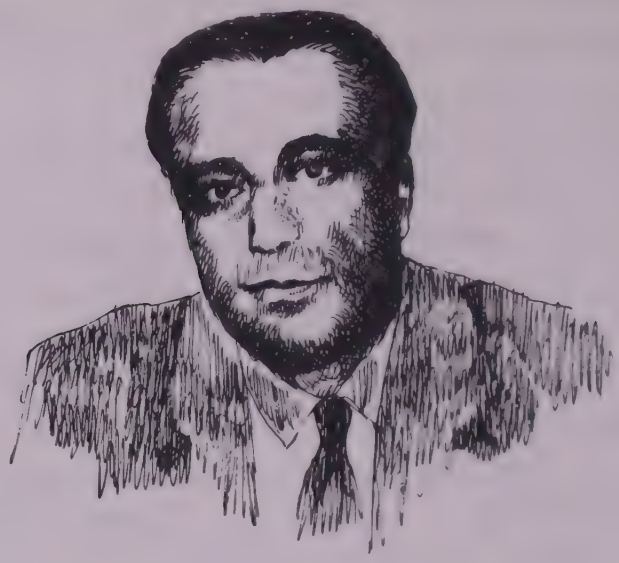
try. To console Wohler for his failure to identify and discover vanadium, Berzelius wrote to him the following letter:

"In the far north there lived in olden times the Goddess Vanadis, beautiful and lovable. One day someone knocked at the door. The goddess remained comfortably seated and thought, 'Let the person knock again'. But there was no more knocking and the one who had knocked went down the steps. The goddess was curious to know who it was. She sprang to the window and saw Wohler going away. After a few days someone knocked again and continued knocking. Finally the goddess herself opened the door. Sefstrom entered and from this union vanadium was born."

BHABHA, HOMI
Atomic physicist (1909-1966)

The Indian atomic physicist, Homi Bhabha was regarded as the father of independent India's scientific ethos and its nuclear programme. He set up with the encouragement of the then Prime Minister Jawaharlal Nehru, a prestigious centre for research in nuclear physics, which later came to be known as the Bhabha Atomic Research Centre. More than anything else, Bhabha is remembered for his unwavering commitment to science and the great hopes he had for the future of science in India.

The attention which Bhabha gave to the planning of the Atomic Centre at Trombay is a legend. What is less known is his role in designing the landscape in and around the Centre. While planning the roads, he observed that an ancient mango tree stood at that very spot where a road was to pass. The civil engineer in charge of building the roads had recommended that the old tree be uprooted so that a straight road could be built. This greatly distressed Bhabha. He strongly felt that the tree, which had lived at the place for more than a hundred years,



had every right to be there. After giving the problem a great deal of attention, Bhabha suggested a realignment of the road in exact civil engineering terms in order to save the tree. Today the tree is still there: old and ancient, like a living monument.

Homi Bhabha, who chose to remain a bachelor, was once asked if he was married. "Yes," he replied and then, with a twinkle in his eye, added, "to creativity!"

BLACK, JOSEPH
Chemist (1728-1799)

Joseph Black is rightly known as the founder of the doctrines on latent heat and specific heat. Lord Brougham, who regularly attended his lectures, paid the following tribute in his memoirs:

"I have heard the greatest understandings of the age giving forth their efforts in their most eloquent tongues, I have heard the commanding periods of Pitt's majestic oratory, the vehemence of Fox's burning declamation...but I would without hesitation prefer, for mere intellectual gratification, to be once more allowed the privilege of being present, while the first philosopher of his age was the historian of his own discoveries, and be an eyewit-

ness of those experiments by which he had formerly made them, once more performed by his own hands."

During those days a professor's stipend was derived largely from fees paid to him by the members attending his class. Lord Brougham, when he first attended his lectures wrote: "When I went to get a ticket for his class, there stood upon his table a small brass instrument for weighing the guineas given. On hearing who I was, he entered into a conversation in a most kind manner... When I turned to go away, he remarked, 'You must have been surprised at my using this instrument to weigh your guineas, but it was before I knew who you were. I am obliged to weigh these when strange students come, there being a very large number who bring light guineas so that I should be defrauded by many pounds every year if I did not act in self-defence against that class of students'."

BOHM, DAVID
Scientist

This American-British scientist is renowned for his current work on quantum reality and his notion of explicate and implicate levels of orders. Bohm completed his doctoral thesis with Robert Oppenheimer during the Second World War. After that he joined the Princeton University, where he met Albert Einstein, with whom he collaborated for a number of years. Bohm is also well known in physics for his book on quantum physics written in 1951.

Bohm's interest in science and the way things work started early. As a young boy growing up in Wilkes-Barre, Pennsylvania, he invented a dripless tea-kettle, and his father, a successful businessman, urged him to market the idea and make a profit on it. He was excited at first, but after learning that the first step in such a venture was to conduct a door-to-door survey to test his

invention, the young David Bohm lost all interest in business.

In 1951, there began the infamous trial of Oppenheimer, for allegedly subversive activities against the US government. David Bohm, who had worked with Oppenheimer as a doctoral student, was then called in by the Senator Joseph McCarthy Committee to testify against Oppenheimer. Bohm refused and as a result was sacked from Princeton University for disobedience. That is when he left the US, never to work there or stay there for long again.

As a child, Bohm liked to climb the hills that surrounded his little town and look down on the streets and houses below. In later life he recalled that his understanding of reality as a web of inter-connectedness was connected to a strong insight he once had when he had climbed the hills. Bohm had been thinking about nature and his own existence when he became overpowered on seeing the lights from the town. The energy from these lights, the young Bohm realised, went out from the town, extending beyond the earth, until it filled the universe itself. Nature, thought Bohm, 'was a web of living energy, each object a mirror made up of strand upon strand of all that is'.

After moving to England in the late fifties, he became a research fellow at London's Birbeck College, from where he retired as a professor of theoretical physics.

BOHR, AAGE
Physicist (1922-)

The son of the illustrious Neils Bohr, Aage was born in 1922, the same year that his father was awarded the Nobel Prize. More than fifty years later, Aage Bohr was also to receive the same award for his work in physics. He took over the directorship of the prestigious Bohr Institute of Theoretical Physics in Denmark after his father left it.

Apart from their shared interest in physics, father and son shared a great sense of humour. Both enjoyed a good joke and proved this in 1951 when together they solved the riddle concerning a new Danish toy, the 'tip-top', that became a true national pest (and earned its inventor a fortune). Once it had been set into motion, the top would continue to spin as if the law of gravity had ceased to exist. But the two scientists solved the problem and Aage Bohr published what in his words was a "simple and obvious explanation", that hardly anybody else understood!

BOHR, NIELS
Physicist (1885-1962)

Danish Nobel laureate in physics in 1922, Niels Bohr is recognised as one of the most accomplished theoretical physicists of all time. He was only twenty-one years old when he was awarded the prestigious gold medal of the Danish Academy of Sciences and Letters, for his original work on experimental and theoretical investigation of the surface tension of water. This was followed four years later by a brilliant doctoral thesis on the electron theory

of metals, which to this day, is considered a classic. His basic ideas on atomic structure were formed in Manchester where he spent four years from 1912 to 1916, working with Rutherford, leading to his papers on the subject in 1913. He was awarded the Nobel Prize for his work on atomic structure in 1922. With the Nazi occupation of Denmark in 1944, Bohr on the advice of his British colleagues, escaped from Copenhagen to Sweden and eventually reached England. Later he was called to America, where he was requested to work on the bomb. Bohr was president of the Danish Academy of Sciences and Letters from 1939 until his death; he founded the Danish Atomic Energy Commission in 1955, the Nordic Institute for Theoretical Atomic Physics in 1957, and took part in the establishment of the prestigious CERN institute.

Since his childhood Niels Bohr was incapable of 'teasing back'. Once his brother Harold, from whom he was inseparable, started teasing him. He stood silent for some time before finally blurting, "You've got a small spot on your coat, Harold."

Niels and Margrethe Bohr were a devoted married couple. He often said that it was Margrethe who made it possible for the harmony between his professional and personal life. Often he used to break off in the middle of a long and tedious discussion, saying: "I'll be back. There is something I must remember to tell my wife." His associates, ready to drop with fatigue, were left behind fully aware that it was nothing important but that Bohr, however untiring, simply needed to obtain strength and inspiration from Margrethe Bohr to get on with his work.

Before fleeing Nazi-occupied Denmark to reach England, Bohr had to live underground, as he was on the wanted list of the Nazis. One day, while going in disguise to a secret laboratory, he bumped into an elderly woman who peered closely at him and said, "Aren't you Professor Bohr?"

Trying to act natural, the physicist laughed and said,

"You must be quite wrong. My name is Baker." On closer inspection, he realised that she was an old and dear family friend, and so he tried to improve on his earlier statement: "Madam, I may be Mr Baker, but you are certainly Mrs Brunn. What a pleasure to meet!"

In spite of the danger of continuing to live in Denmark, Bohr was unwilling to leave his institute and his associates among whom were Jewish refugees. But the situation became so critical in September 1943 that he and his wife were compelled to seek refuge in Sweden. From there, he flew to England in a tiny 'mosquito'. It was a dangerous expedition—the small unarmed plane had to fly through German controlled airspace and worse still, Bohr had to crouch in the bomb-storage area, as that was the only place for a passenger. Moreover, the oxygen supply failed and Bohr barely made it to England.

Bohr eventually landed in New York, along with his son Aage, accompanied by two British detectives. Here, the party was joined by two secret service agents of the Manhattan Project Organisation and two officers of the FBI (Federal Bureau of Investigation). Bohr disliked being shadowed by half a dozen watchdogs and kept trying to slip away from them. What he ended up doing was cross the streets of New York at the oddest and prohibited places, compelling six guardians of the law to join him in breaking traffic regulations!

On way to the bomb project in Los Alamos for the first time, he was given a lecture by General Groves in the train on what to say and what not to. Bohr kept nodding. "Within five minutes of his arrival," reported the General later, "he was saying everything he promised he would not say."

Though critical of the consequences of the research he was asked to do on developing the bomb, Bohr also foresaw the necessity for the bomb, saying that it might make future wars impossible. A genuine humanitarian and a pacificist, Bohr endeavoured to appeal to

statesmen and politicians, calling for a policy of openness, which as expected was ignored. In 1950, he made an appeal to the United Nations, publicly advocating his policy of free exchange of information as the first step in restoring mutual confidence and understanding between nations.

Bohr became an addict of American western movies with titles such as 'The Gun Fight at the Lazy Gee Ranch' and 'The Lone Ranger' and 'The Sioux Girl'. George Gamow reminisced: "One of our duties was to take Niels to the movies and explain the plot to him. He was a slow thinker and kept asking questions, 'Is this the sister of the cowboy who tried to steal the herd of cattle belonging to her brother-in-law'?"

During a serious discussion on quantum processes, some physicists including Bohr took to laughing wildly. A newcomer found this, in some way, disrespectful. Bohr drew on his pipe and explained with a gentle smile, "There are some things that are so serious that you can only joke about them."

Bohr was dictating a few sentences to Pais. He suddenly halted at the word 'Einstein'. Then he started running around the table, repeating 'Einstein, Einstein, Einstein'. Suddenly he stopped to look out of the window, still repeating the name. At that instant the door opened softly and Einstein stuck his head in. As soon as he heard his name being repeated by Bohr, he put his finger to his lips in a signal to Pais to remain silent, and to Pais' surprise, tiptoed over to stand just behind Bohr. At that instant, Bohr, with another (firmer) 'EINSTEIN', turned around. "They were face to face, as if Bohr had summoned him forth," said Pais later. "For some time, Bohr stood there in frozen shock. Only after a few minutes was the tableau broken. Then we all burst into laughter."

"It's mind-boggling," a young physicist complained after a long and abstract discourse by Bohr.

"If it doesn't boggle your mind, you don't understand anything," replied Bohr.

When Niels Bohr visited the Physics Institute of the Academy of Sciences, USSR, he was questioned on how he had succeeded in creating a first-rate school of physicists. His reply was, "Presumably because I was never embarrassed to confess to my students that I am a fool..."

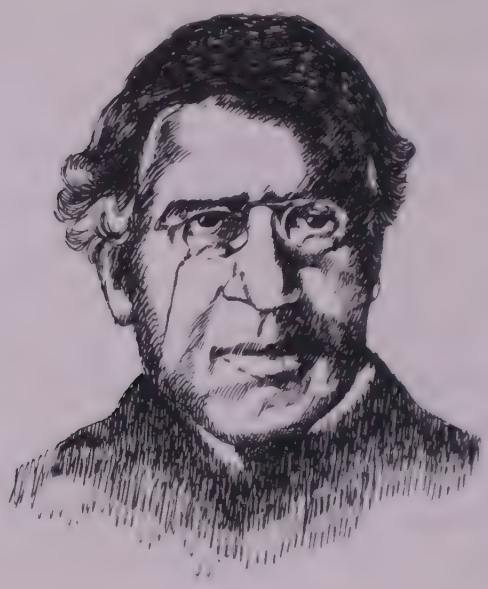
When Bohr was engaged in something he always felt a need for discussing it with others. A conversation with Bohr went, as he himself did, in circles when he spoke. Round and round he wandered on his own track with a sovereignty that was made beautiful by his loving smile as he encircled both his subject and his audience in narrower and narrower circuits. And as a passionate pipe-smoker, he lit matches all the time whether his pipe was lit or not. Bohr's consumption of matches was legendary. He could not manage with the ordinary small boxes but always carried around gigantic boxes of matches with him. Once Bohr was lecturing to his students when one of them asked about the direction physics would take. Unperturbed, he quoted from Goethe's *Faust*, "What is the path? There is no path. On into the unknown."

In 1947, Bohr received the Order of the Elephant, the highest honour awarded to Danes who are not members of the Royal family. When it came to choosing his coat of arms, that would be placed in the Frederiksborg Castle, he unhesitatingly chose the Chinese symbol of Yin-Yang, the two opposite elements that compliment each other, and which together describe the whole world.

After the war Niels Bohr returned to Denmark and visited his institution. He was received with cheers and happy tears by his academic staff. He was taken round the laboratory to see in a bottle dissolved noble metals which subsequently were recovered and recast.

BOSE, SIR JAGADISH CHANDRA
Physicist-biologist (1858-1937)

An Indian plant physiologist and physicist, Jagadish



Chandra Bose was one of the pioneers of modern science in India. His early research was on the properties of electric waves, which contributed very significantly to further research in the subject. His major achievement was to demonstrate the similarity of responses to stimuli among the living and the non-living as well as the fundamental similarity of responses in plant and animal tissues. To carry out his research in this extraordinary field, he invented the crescograph, which records plant growth. Among his well-known published works are *Responses in the Living and Non-Living* and *Plant Responses*.

He was knighted by the British government in 1917 and in the same year, he founded the Bose Research Institute in Calcutta, of which he was Director till his death in 1937.

When the young Bose joined a missionary school in Calcutta, he found himself taunted and ridiculed by the European and Anglo-Indian boys, who were amused by his humble, rural background. One of the boys was a boxer who kept bullying Jagadish. One day, unable to tolerate the growing ridicule and the bullying, Jagadish challenged the other student to a fight and then beat him squarely. This earned him self-respect and no one dared to tease him after that.

All the great scientists of London had assembled to witness Bose's experiment to prove that plants also have life. When the plant did not die as expected after he had injected it with a poison, Bose was unperturbed. He simply said, "The poison did not kill the plant. So it should not kill me, another living being." So, just to make sure, he brought the injection syringe close to his left arm to inject its contents into his body.

At that moment a man got up and said, "I accept my defeat, Mr Bose. It was I who replaced the vial of poison with coloured water." Needless to say the experiment was successful the second time around.

Bose's interest in botany and physiology was in part a reversion to his early childhood passion and a reaction to what he considered was a western emphasis on specialisation. He believed that by focussing on the boundaries between different physical and biological sciences, he would be able to demonstrate the underlying unity of all things. In one of his writings, Bose wrote, "In my scientific research...an unconscious theological bias was also present...It is forgotten that He, who surrounded us with this ever-evolving mystery of creation, the ineffable wonder that lies hidden in the microcosm of the dust particle enclosing within the intricacies of its atomic form all the mystery of the cosmos, has also implanted in us the desire to question and understand."

Bose believed that the true scientist must learn to evoke, look and listen, rather than probe and analyse from a distance. After discovering a resonant and oscillating recorder which measured the electric response of plants to external stimuli, Bose commented: "It has been beautifully said—and it is a law of the moral world as unchangeable as physical laws: 'Ask and it shall be given to you; seek and ye shall find; knock and it shall be opened to you'."

Bose's biological researches were prompted initially by the discovery that an electric receiver seems to show

signs of fatigue after continued use. He began to wonder how far it was legitimate to compare the responses of living and inert matter to external stimuli, and whether or not plants could be shown to possess some sort of latent consciousness. He was, however, unable to progress very far, and the evaluation of his work in the 1945 edition of the *Encyclopaedia Britannica*—eight years after his death—was a fair one: "His research was so much in advance of his time that precise evaluation is not possible."

After completing his studies in London, Bose returned to Calcutta and was appointed professor at the Presidency College in Calcutta. However, his salary was kept at two-thirds that of a European and was further halved as he was supposed to be officiating only. Bose's protest against this injustice was unique and typical of the man. He accepted the job, but refused to take his salary cheque for the next three years. Finally realising the value of his work and by a special order from His Majesty's government, his demand was conceded and he was paid full salary with retrospective effect for all three years.

BOSE, SATYENDRA NATH
Mathematician (1894-1974)

This Indian mathematician made enormous contribution to the subject of quantum statistics. Together with Einstein, Bose suggested a statistical description of quantum mechanical systems in which there is no restriction on the way in which the energy of particles can be distributed. The theory subsequently came to be described as the Bose-Einstein Statistics.

As a Reader in physics at Dacca University, in the year 1923, Satyendra Nath Bose submitted a paper in quantum physics for publication in the research magazine of the university. The paper was rejected by the editorial board. Undaunted, Bose sent the paper to none

other than Einstein, with a respectful letter asking him whether it could be published in *Zeitschrift fur Physik*. He also requested Einstein to translate the paper as his own German was very weak. Einstein not only translated the paper and had it published, but appended it with the line, "Bose's method of derivation...in my opinion signifies a forward step."

On another occasion Niels Bohr was delivering a lecture, S.N. Bose was in the chair. Bohr was writing on the blackboard trying to explain a point, but finding it a difficult task turned to Bose and asked, "Can Professor Bose help me?"

Bose had been sitting with his eyes closed throughout the discourse. A titter ran through the audience. To everyone's astonishment, Bose opened his eyes, got up, solved the problem, sat down and closed his eyes again!

International recognition eluded Bose for a long time. Thirty-four years after his discovery of the behaviour of radiation, he was elected fellow of the Royal Society. On several occasions, he had to take testimonials from relatively more famous physicists like Einstein to convince the authorities of his worth. He could talk on any subject: from the price of fish to the latest problem in physics.

At an international seminar in Calcutta held to felicitate his work, Bose said that he had no desire to live any longer as his work was finally being recognised all over the world. A month later, he died.

BRAGG, SIR WILLIAM HENRY
Physicist (1862-1942)

One of the original greats of science, Sir William Bragg had a brilliant record as a mathematician at Cambridge, after which he taught and researched at the University of Adelaide in Australia for over fifteen years. Returning to

England, he became the Cavendish professor at Leeds, where he built the first X-ray spectrometer. In 1915, the year that he was awarded the Nobel Prize along with his son, he became professor of physics at London University and subsequently resident professor and Director of the laboratories of the Royal Institution.

Bragg's career as a scientist, was, to put it mildly, unusual in many ways. Although he was trained as a mathematician, he had absolutely no inkling of physics. However, he found himself appointed as professor of physics and mathematics at Adelaide University, where he had to literally teach himself physics before he could teach his students. Regarding laboratory work, having hardly used any apparatus, Bragg began by learning how to use a lathe. He then ended up devising whatever was needed for the practicals himself. As a result, he developed such a keenness for instrumental design that it was reflected later in all his experimental work. Although he had never done any research whatsoever until he was forty-two, it took him only a few years to gain international repute.

The nature of light has always been a problem for scientists. Referring to its peculiarities, Sir William Bragg once remarked, "Light behaves like waves on Mondays, Wednesdays and Fridays, like particles on Tuesdays, Thursdays and Saturdays, and like nothing on Sundays."

Sir Bragg took active part in the educational films meant for schools. The director of the film once pointed out that due to a particular scene which. was not upto the mark, the entire sequence would have to be redone. It required Bragg to put on the same suit which he had worn in an earlier shot. Unfortunately that suit had been sold off by his wife at a jumble sale. Somehow his wife managed to secure the coat but not the trousers. Sir Bragg had to request the director to take the missing shot on him from the waist upwards and not of his legs. Such a predicament was a unique experience for him.

BRAGG, SIR WILLIAM LAWRENCE
Physicist (1890-1971)

This illustrious son and the equally illustrious father were uniquely credited for keeping the Nobel Prize for physics in 1915 within the family. They did fundamental work on determination of the crystal structure by means of X-ray diffraction.

William Lawrence Bragg was born in Adelaide where his father was teaching at the time. During the First World War, he was a technical advisor on sound ranging for the British Army, perfecting methods of locating enemy guns by sound triangulation methods. In 1921, he was elected a fellow of the Royal Society; in 1938, he became the Cavendish professor at Cambridge; in 1941, he was knighted. From 1954 to 1966, he was Director of the Royal Institution of England, carrying on the tradition of popularising science that had begun with Sir Humphrey Davy, Michael Faraday and John Tyndall.

In 1912, Max von Laue in Germany published a paper in which he announced that crystals apparently acted like three-dimensional diffraction gratings when X-rays passed through them, thereby supporting the theory that X-rays are electromagnetic waves rather than particles. The elder Bragg, however, had developed a theory that said exactly the contrary and he set about checking von Laue's results in order to disprove them. To do this, he first invented the X-ray spectrometer. Meanwhile the younger Bragg had returned to his studies at Cambridge and slowly became convinced that his father was totally wrong. More importantly, he went further and predicted that the diffraction patterns were actually a representation of the location of atoms in crystals. This is where his father's invention of the spectrometer became useful; the two Braggs turned to the analysis of crystal structure and founded modern crystallography!

BRAHE, TYCHO DE
Astronomer (1546-1601)

The Danish astronomer, who is well known as the discoverer of the 'new star' in Cassiopeia, was one of the famous practical astronomers of the late renaissance. Brahe was the son of a Danish nobleman and studied at Copenhagen, Leipzig, Rostock and Augsburg. He discovered the famous 'new star' on 11 November 1572. Tycho Brahe was the first to allow for the effect of refraction by the earth's atmosphere on astronomical observations and introduced methods for correction of instrumental errors and the averaging of accidental errors.

Tycho's father was Governor of the Elsinore Castle and his uncle, a country squire and Vice-Admiral. This uncle, being childless, had extracted a promise from his brother, the Governor, that if the latter had a son, he would adopt him and bring him up as his own. However, after a son was born to the Governor's wife, he went back on his agreement. The uncle retaliated by kidnapping the baby who was none other than Tycho.

As a student, Tycho fought a duel with another noble Danish youth over a dispute regarding who was the better mathematician of the two. In the process, a big part of Tycho's nose was cut off. This was replaced by a gold

and silver alloy, which gave his nose a rectilinear shape. With his bald and large egg-shaped head and an oversized handle-bar moustache, the cubistic nose gave Tycho Brahe quite an appearance.

Tycho's reputation had been established by now and he spent much of his time travelling widely in Europe, visiting friends and astronomers. One who impressed him most was Wilhelm IV in Cassel, in Germany. He had built himself an observatory on a tower in Cassel, and so devoted was he to astronomy that, when told that his house was on fire while he was observing a new star with Tycho Brahe, he calmly finished his observation, while his house was going up in flames!

King Frederick II of Denmark was a patron of philosophy and the arts. Moreover, his life had been once saved by Tycho's foster-father, the Vice-Admiral. Now eager to preserve Tycho Brahe for Denmark, Frederick offered him a choice of several castles, which were however found unacceptable. Finally, he lured Brahe, who had almost settled in Germany, by offering him an entire island called Hveen between Copenhagen and the Elsinore Castle. It was three miles in length and extended over two thousand acres of flat table-land rising on sheer white cliffs out of the sea. In addition to a castle and an observatory, Tycho Brahe was given an annual grant plus various funds that made him the highest paid man in Denmark. Tycho no doubt accepted the offer.

The fortress that Tycho Brahe built on Hveen was monstrous. The basement had his own printing press, fed by his own papermill, his alchemist's furnace and his private dungeon. There was also a huge underground observatory with only their domes extending over the earth's surface. There were all kinds of gadgets, including statues that turned on hidden mechanisms, and a communication system that enabled Tycho to ring a bell in the room of any of his assistants—which made his guests believe that he was invoking them by magic.

In the midst of all this splendour, Tycho Brahe was going to seed. He is described as a pompous and arrogant figure who kept rubbing ointment on his alloyed nose while presiding over the extravagant banquets that were regularly held on the island. He also had a fool, called Jeppe, who sat at his master's feet under the table, chattering incessantly amidst the general noise. He was a dwarf, reputed to have had second sight; and Tycho Brahe would throw casual left-overs of food to him.

The only thing missing from his island was his tame elk. It had been dispatched to him from his estate, but never reached the island. While spending a transit night at Landskroner Castle, the prized elk wandered up the stairs to an empty apartment where it drank so much strong beer that on its way downstairs, it stumbled, broke its leg and died!

BUNSEN, ROBERT WILHELM VON
Chemist (1811-1899)

The German chemist, who is widely known as the inventor of the Bunsen burner, was also the co-founder of chemical spectroscopy. His first paper on the subject was published in 1859, which stated that every chemical element was characterised by a particular spectrum. Using this tool, he was the first to prepare analytically pure compounds of potassium, sodium, lithium, barium, strontium and calcium. Bunsen and Kirchhoff also predicted that the spectrum analysis would lead to the prediction of new elements. And a year later, rubidium and cesium were discovered by means of spectroscopy.

Attendance during Bunsen's lectures was optional. Yet at the end of the term students had to get a signed certificate from the professor. One student who had assiduously avoided Bunsen's lectures for a whole term, approached him for a certificate of attendance. Seeing the unfamiliar face, Bunsen remarked, "I have never seen you at a lecture."

The student immediately replied, "Professor, you see, I always sit behind the pillar in the classroom."

Bunsen retorted, "Ah, what a lot of you sit there!"

Bunsen was often absent-minded and his difficulty in remembering names was legendary. One day a known visitor called, whose name eluded Bunsen. He however managed to narrow his guess down to possible names: Kekule or Strecker. During the conversation, he tried without any success in figuring out which of the two gentlemen was his caller. At last he decided that it had to be Kekule. When the visitor finally rose to leave, a confident Bunsen could not refrain from remarking, "Do you know, that for a moment I took you for Strecker!"

"That's who I am!" replied his visitor in astonishment.

When the 500th anniversary of Heidelberg University was celebrated in 1886, an elaborate breakfast was served, which lasted for more than three hours. Bunsen soon fell into a deep slumber as the tiresome speeches began but, at one place, a speaker's loud oratory caused the chemist to awake with a start. Rubbing his eyes, he mumbled to his neighbour, "I thought I had let a test-tube full of rubidium fall to the floor!"

On another occasion, an English woman to whom he had just been introduced, mistook him for Josias Bunsen, the ambassador, and asked him if he had finished his book *Gott in der Geschichte* (God in History).

"Alas," replied Bunsen, "my untimely death prevented me!"

Bunsen was extremely modest when he found it necesssary to mention his own discoveries in his lectures, and he would say, *Man hat gefunden* (It has been discovered), never using the word 'I'.

Bunsen won many honours and medals, but of these he once said sadly, "Such things had value for me only because they pleased my mother; she is now dead."

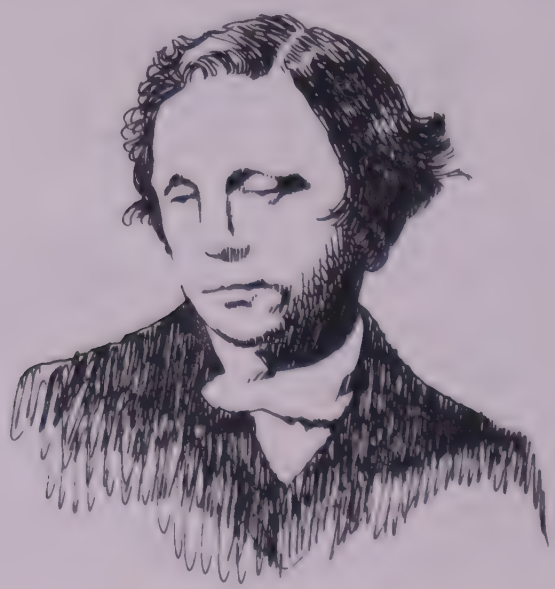
Bunsen had a very sharp mind and he persevered

tirelessly. Rosco said of him: "Original scientific work is measured by the new paths and new fields which such work open out. In this respect, the labours of Bunsen stand second to those of no chemist of his time."

Sir E. Thrope spoke thus of him: "Before Bunsen gave a piece of apparatus to the chemical world, he left it perfectly perfect. The striving after perfection was a veritable passion with him."

CARROLL, LEWIS
Writer-mathematician (1832-1898)

British mathematician and writer, Lewis Carroll is best known as the author of *Alice's Adventures in Wonderland,* which was published in 1865. His real name was Charles Lutwidge Dodgson and he graduated with honours in mathematics, after which he became a lecturer at Christ Church, Oxford. Under his real name, he published a number of mathematical works, including *Euclid and Modern Rivals, Curiosa Mathematica* and *Symbolic Logic.* He gained enormous success and international recognition with the publication of *Alice's Adventures in Wonderland.* His fame during his lifetime was further enhanced by his outstanding photography of children.



Lewis Carroll gave the following practical advice on problem solving. "When I come upon anything—in logic or in any difficult subject—that entirely puzzles me, I find it a capital plan to talk it over aloud to myself. One can explain things so clearly to oneself...one never gets irritated at one's own stupidity."

Lewis Carroll had a rather bad stammer, which imbued a sense of insecurity in him, keeping him away from the company of others. However, the affliction completely disappeared when he was in the company of children!

CAVENDISH, HENRY
Chemist-physicist (1731-1810)

British chemist and physicist Cavendish is best known for the determination of Newton's gravitational constant and for his research in gas chemistry and electrical theory. Apart from being one of the greatest scientists of his time, Cavendish was also one of the wealthiest men of his days. He had several houses in London and also a library in Soho. He began as an assistant in his father's laboratory, where he started his research to pursue single-mindedly for over fifty years. He was elected fellow of the Royal Society of London in 1760. He was the first to discover the separate existence of hydrogen and moreover, was the first to synthesise water from hydrogen and oxygen. He also went on to produce nitric acid from a mixture of nitrogen, oxygen and water vapour, and discovered that nitrogen was a constituent of nitric acid. Cavendish was also the first to propose that every charged body was surrounded by an 'electric atmosphere'—a major step towards the formulation of the electric field theory. The torsion balance that is so widely used in laboratories bears his name, with which, in 1798, he determined the value of the gravitational constant.

Cavendish was an extremely shy and awkward man

and to him all men were strangers. The only social contacts he ever made were at the meetings of the Royal Society and the Sunday evening receptions of Sir Joseph Banks for scientists in London. He spoke falteringly and in shrill tones and was totally unable to converse with more than one person at a time. A distinguished Austrian scientist was once introduced to Cavendish with extravagant praise. The foreign guest in turn, became profuse in his flattery of Cavendish, saying that he had come to London especially to meet him, whereupon Cavendish, at first embarrassed, then utterly confused, darted through the crowd like a rabbit, where his carriage was waiting, jumped into it and disappeared.

Dr Wollaston, however, had discovered a method of overcoming this diffidence in Cavendish. "The way to talk to Cavendish," he said, "is never to look at him, but to talk as if it were into vacancy, and then it is not unlikely that you may set him going."

A confirmed misogynist, Cavendish never married or entered into any liaison with the feminine sex. Returning home one day, he saw a female servant with a broom and pail on the staircase. So annoyed was he that he immediately ordered a new back staircase to be built! (He had already dismissed a number of maids who had crossed his path in the house). Once before, as he was climbing over a stile, he observed to his horror that he was being watched by two ladies. He forsook that road forever and took his solitary walks only when it was dark enough.

Cavendish was noted for his idiosyncracies, which sometimes ran into the absurd. For example, every time he took a book from his personal library at home, he never forgot to sign the book card!

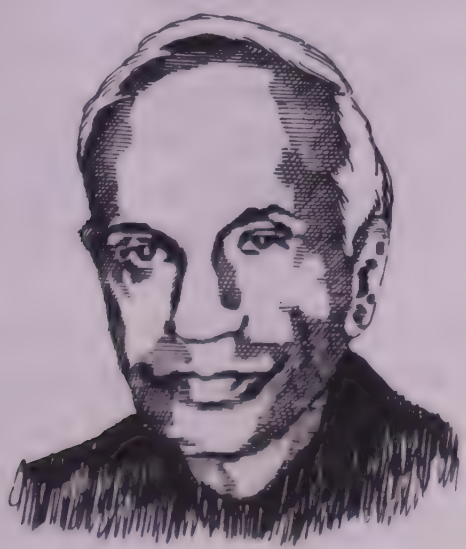
During his father's lifetime, Cavendish lived on a meagre allowance, but after his father's death, he received an enormous inheritance. Soon another aunt died, leaving him another large legacy. He thus became, as Biot said, "the richest of all the learned and the most learned

of all the rich." But he continued to live very modestly and the interest on his inheritance kept accumulating until, at the time of his death, he was the largest depositor in the Bank of England.

Cavendish's death was as lonely as his life. He lived to be seventy-nine, and then, one day, feeling death approaching, he asked his attendant to leave the room and return at a specific time. When the attendant returned, he found Cavendish dead. It was the end of a blameless life, unselfishly devoted to the advancement of science.

CHANDRASEKHAR, S.
Astronomer-mathematician

India-born American astronomer and mathematician, who was awarded the Nobel Prize for astronomy, acquired fame for his work on 'Relativistic Degeneracy of Stars'. Initially a fellow at Trinity College in England, he moved to the University of Chicago where he worked at the Yerke's observatory for twenty-seven years. In between, during wartime, he was specially hand-picked by John von Neumann to work at the ballistic research laboratory in Maryland. From 1952 to 1971, he was also the managing editor of the renowned *Astrophysical Journal*.



Chandrasekhar was born in an intellectually-minded family, where higher education in England was a matter of tradition. After completing his undergraduate studies in India, the young Chandra almost succumbed to the pressure of tradition to appear for the prestigious Indian Civil Service examination. His mother stood by him and urged Chandra to further his prodigious mathematical talents by going to Cambridge on a Government of India scholarship. When he departed, it was for the last time he was to see his mother, as she died soon afterwards.

While at Cambridge, Chandrasekhar became involved in the well-known controversy with Sir Arthur Eddington, who after mentoring the younger scientist, turned his back on him by branding Chandrasekhar's work as fallacious. Eddington was obviously peeved at Chandrasekhar's brilliance and growing recognition and kept justifying his stance with obscure and irrational arguments, even when reputed physicists and mathematicians like Wolfgang Pauli, Paul Dirac and Ronald Peierls supported Chandra's derivation of the relativistic equation. Ironically, he received the Nobel Prize for his work, more than thirty years later!

Chandrasekhar's indebtedness to his wife Lalitha for transforming his views is obvious in his *Scientific Biography*. Unlike his family, which although belonged to the intellectual elite but had a tradition of preventing girls from advanced education for the sake of an early marriage, Lalitha's family was enlightened enough not to. It meant a great deal to Chandrasekhar since both his sisters had been denied education, being given away in early marriages, and causing him a lot of unhappiness in return.

As managing editor of the *Astrophysical Journal*, Chandrasekhar's style of work was legendary. He personally read, corrected and edited all the papers for publication, and demanded the same meticulous standards in manuscript preparation, whether the writers

happened to be young scientists or Nobel laureates. During his tenure he transformed the journal from being a private journal of the University of Chicago into a national journal of the American Astronomical Society.

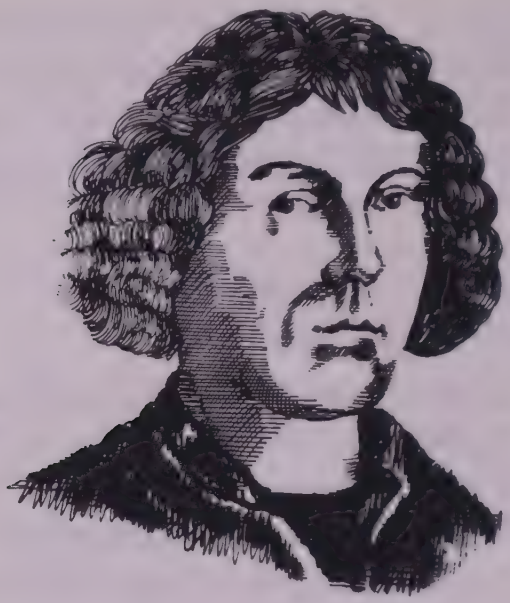
CHARLES, JACQUES ALEXANDRE CESAR
Mathematician-physicist (1746-1823)

The French mathematician and physicist was the first in 1783 to use hydrogen for the inflation of balloons. Charles also anticipated Gay-Lussac's law of the expansion of gases with heat, which on that account is known by his name. He also improved the Greaves and heliostat and the aerometer of Fahrenheit, and invented a thermometric hydrometer, and many other ingenious physical devices.

Within nine days of the Montgolfiers Brothers' ascent in a hot-air balloon, Prof. Alexander Charles got his hydrogen balloon ready. The ascent was scheduled for the first of December in the year 1783. However, at the last minute, a police officer intervened and prevented the distinguished professor from making the flight as it was too dangerous. When Alexandre Charles tried to insist on boarding the balloon, the officer ordered his men to hold him down physically. Acting on the spur of the moment the professor sent word to the royal court that if he were not permitted to board the balloon, he would shoot himself on the spot, "taking the secret of my invention into the grave." Within an hour's time, the royal sanction came and the balloon, with its eccentric inventor on board, rose majestically into the sky.

COPERNICUS, NICOLAUS
Astronomer (1473-1543)

The Polish astronomer and thinker, whose work made an invaluable contribution to the birth of science and the



consequent theories that emerged in physics, made possible the reformation of traditionally held ideas about the universe and spawned what in retrospect is known as the Copernican revolution. He studied mathematics, astronomy, law, and medicine at Cracow, Bologna and Padua and received his doctorate at Ferrara. During the early stage of his career, Copernicus became aware of serious defects in the Ptolemaic system that he had learned as a student, which years later led to his final work in astronomy. In the year 1543, his masterpiece, *The Revolution of the Heavenly Spheres*, was published, bringing the totality of his revolutionary work in astronomy into the open.

When the members of the Teutonic Order heard that Copernicus was trying to prove the falsity of the Ptolemaic system of planetary motion, they decided to ridicule him. They hired a number of clowns to go about the villages and mock his astronomical studies. And then they would impersonate Copernicus, whom they called a 'crazy priest'. When Copernicus was told about this by his friends, he only smiled. "Let them be," he said. "The movement of the heavenly bodies will be influenced not in the slightest either by the ridicule or the respect of these foolish men."

In his sixty-ninth year, after much hesitation, Copernicus finally decided to have his revolutionary theory published. Since he was too old to attend to the publication, he entrusted it to his friend, Tidemann Gysius, the bishop of Culm. When the book was finally published, Copernicus was on his death-bed. His body had been paralysed some weeks earlier. When the book was opened for him to read, his eyes came to rest on a strange preface. 'This book', it read, 'is written to present not a scientific fact but a playful fancy.' Copernicus was heartbroken. He died the same day.

The earliest monument to Copernicus, in St. John's Church in his native Torun, has a curious inscription which was copied from a note found in his pocket after he had died. It goes like this:

I crave not the grace bestowed on Paul
Nor the remission granted to Peter
Only forgive me, I fervently pray
As thou forgavest the crucified thieves.

CRICK, FRANCIS
Biologist (1916-1953)

This British biophysicist and geneticist shared the 1962 Nobel Prize in physiology with Maurice Wilkins and James Watson for their discovery of the molecular structure of DNA. Crick originally studied physics at University College, London but the outbreak of the Second World War halted his doctoral research. For the next eight years, from 1939 to 1946, he worked for the British admiralty.

Francis Crick shared the Nobel Prize with James Watson who wrote the famous scientific autobiography *The Double Helix*. When the research paper meant for publication in *Nature* had to be typed, Watson sought his sister's help to type out the important thesis. He persuaded her by telling her that she was "participating in

perhaps the most famous event in biology since Darwin's book". This shows in how great esteem he held Francis Crick.

After the war, he decided to take up biology as a career. By 1953, he and James Watson had formulated the complementary double helical structure of the DNA molecule.

Being a Nobel laureate also means coping with a deluge of invitations from innumerable institutions, a ritual that can be quite taxing. Francis Crick devised his own way of dealing with the demands. He drafted a standardised check-list that he would have filled. It ran like this:

Send an autograph
provide a photograph
cure your disease
be interviewed
help you in your project
talk on the radio
appear on the TV
speak after dinner
read your manuscript
deliver a lecture
attend a conference
act as chairman
become an editor
write a book
accept an honorary degree.

CURIE, MARIE (MARJA) SKLODOWSKA and CURIE, PIERRE
(1867-1934) and (1859-1906)

The two French scientists jointly received the Nobel Prize for physics in 1903 for their work on radioactivity. Pierre Curie studied physics at Sorbonne and at the age of nineteen was appointed a teaching assistant and Director of labo-

ratory instruction at the Paris Faculty of Sciences. In 1880, with his brother Jacques, he discovered piezoelectricity. About 1891, Pierre began an investigation of magnetism at high temperatures, leading subsequently to the discovery of the Curie point, after which further research led to the formulation of Curie's law.

Marie Sklodowska was born in Poland and moved to Paris in 1891, where she studied mathematics, physics and chemistry at Sorbonne. Marie and Pierre were married in 1895, drawn together by their mutual interest in magnetism. After Becquerel discovered that uranium salts emitted rays that resembled X-rays, the Curies set out to discover whether there were other substances that emitted such rays. They finally managed to isolate the radium metal in 1910.

The Curies had two daughters, Joliot and Eve. Joliot went on to win the Nobel Prize in chemistry and Eve became a well-known writer. Pierre was elected to the Academy of Sciences in 1905, but died a year later in a tragic accident. Marie Curie was awarded another Nobel Prize in 1911, this time in chemistry.

When Marja's father asked her what she would like to do with her life, her response was immediate, "I would

like to to go to Paris to study medicine. Women are admitted at the university there."

Her father shook his head sadly and said, "There is nothing better for you, but your elder sister has expressed the same wish. We cannot afford to send even one of you. What shall we do?"

Marja's pretty face grew firm and her pale eyes looked determined. "Very well, Pronja shall go, I shall stay here and work to support her. When she is a doctor, she will help me to follow." More than five long years were to pass and Marja continued to work as a governess for a pittance, supporting her sister's studies. Eventually, she could make it to Paris.

While at Sorbonne, Marie Sklodowska led the life of a monk. Her residence was a sixth-floor attic, hired at fifteen francs a month. A crevice in the slanted ceiling brought in a little bit of light. In the evenings and nights, it used to be chilly and damp as there was no heater in the room. Nor was there any running water. Marie's daily diet used to be bread and tea, with the luxury of an egg on rare occasions. In the cold winter she would put a handful of coal into a toy stove and sit in front of it, doing her equations. One day, during a morning class, she fainted. When she recovered, they discovered that in the last twenty-four hours she had eaten nothing but a few radishes.

After their marriage in 1895, Professor Schuetzenberger arranged that the Curies might work together in the laboratory. Their mutual devotion to science led Pierre Curie to remark, "I have got a wife made expressly for me to share all my preoccupations."

"One of our joys," wrote Marie Curie, "was to go into our workroom at night; we then perceived on all sides the feebly luminous silhouettes of the bottles containing our products. It was really a lovely sight and always new to us. The glowing tubes looked like faint fairy-lights."

Only on one occasion did Pierre Curie allow his name to be presented for distinction. On the insistence of his scientist friends, he became a candidate for the Academy of Sciences, only because he knew the post would bring him a laboratory. Every candidate was expected to visit the houses of the members of the academy, canvassing his qualifications. Curie however found this exercise to be an inhuman ordeal. As a consequence he found himself playing up his opponent's qualifications at the expense of his own, and so, the academy elected the opponent.

Wrote Wilhelm Ostwald in his autobiography, "At my urgent request, I was shown the Curie laboratory, in which radium had been discovered a short time ago. The Curies themselves were travelling at that time. To my great surprise, I found it to be a cross between a horse-stable and a potato cellar, and if I had not seen the work-table with the chemical apparatus, I would have thought it a practical joke."

When the Dean of Sorbonne wrote to Pierre Curie that the Minister had proposed his name for the Legion of Honour, he replied: "Please be so kind as to thank the Minister and inform him that I do not feel the slightest need of being decorated, but that I am in the greatest need of a laboratory."

Soon after its discovery, radium was found effective in the treatment of cancer and was valued at 150,000 dollars a gramme. The home of the Curies was immediately flooded with friends and well-wishers who urged upon them the necessity of patenting the process of extracting radium. But the Curies refused to capitalise on their discovery. "Radium is an instrument of mercy and it belongs to the world," they said.

Marie's simple disguise for avoiding recognition was to remain undisguised. One day an American reporter, hot on the trail of the elusive Curies, managed to locate their vacation hideout which was a fishing village off

Brittany. He soon found the Curie cottage and arrived there to find a peasant-like woman sitting barefoot on the doorstep. "Are you the housekeeper of this place?" asked the reporter.

"Yes," replied Marie.

"Is the lady inside?" persisted the reporter.

The woman replied, "No, she is out."

"Could you tell me something intimate about her?" was the next question, as the reporter planted himself on the doorstep.

"Nothing," replied Marie Curie, "except one message that Madam told me to convey to reporters: 'Be less inquisitive about people and more inquisitive about ideas'."

Speaking of Marie Curie, Albert Einstein once remarked, "Marie is, among all distinguished people, the only one whom fame has not corrupted."

Marie Curie thoroughly despised the honours that she kept receiving. She threw away all the titles and medals soon after she received them. The only thing she would retain were the menus from the banquets that she had to attend. The reason for this was that the menus were made of thick cardboard and were useful for scribbling down her mathematical calculations.

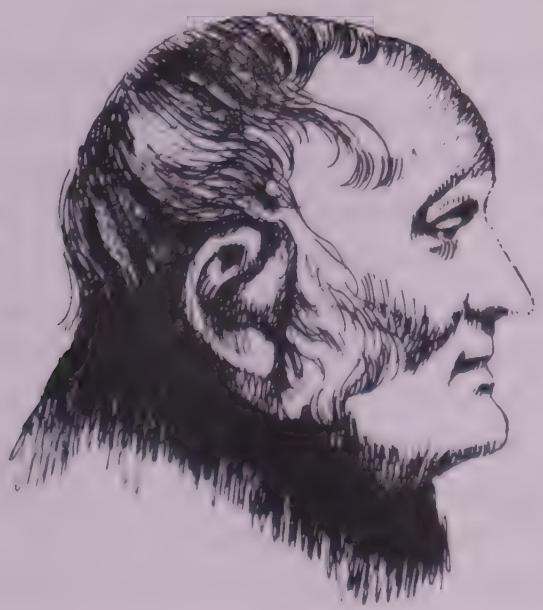
Marie and Pierre's life toghether came to an abrupt end when Pierre was run over and killed instanly on the Rue Dauphine in Paris. Marie's devotion to science grew even more. She became the only person ever to have been awarded the Nobel Prize in both physics and chemistry. However, in spite of this, the Academy of Sciences refused to abandon its prejudice against women, and she failed to be elected as its member.

Marie Curie summarised her life story in these words: "I was born in Warsaw of a family of teachers. I married Pierre Curie and had two children. I have done my work in France."

DALTON, JOHN
Chemist (1766-1844)

Dalton was a British chemist and physicist, who developed an atomic theory in which elements are characterised by different sizes and weights. Largely self-taught, Dalton began as a teacher, but owing to the poor wages, became a farm worker. Later on in 1793, Dalton became a lecturer in mathematics and natural philosophy at New College in Manchester. The atomic theory with which Dalton's name is associated, originated during his meteorological interests in 1801. Dalton was convinced that nature works in simple ways, and this is reflected in his law of partial pressures. His own account of his atomic investigation appeared in *A New System of Chemical Philosophy*, which was published in separate parts in 1808, 1810 and 1827. He was elected a fellow of the Royal Society in 1822 and in 1830, became one of the eight foreign associates of the French Academy of Sciences.

In 1794, Dalton was elected member of the Manchester Literary and Philosophical Society. One Sunday, some of his friends remarked on the impropriety of his wearing a deep red coat to the meeting of the society. Dalton was astounded, for, to him the coat was a modest brown. He



then discovered that he simply could not see red and that he could only recognise blue, purple and yellow. His first paper in the journal of the society was the initial scientific account of colour blindness, later to be called Daltonism after him.

On becoming aware of his handicap, he used it to advantage. When he was to be presented to the King, etiquette required that he wear the court dress, or his Oxford robes that were scarlet. Being a Quaker, he was forbidden to wear scarlet. Fortunately his colour blindness came to his rescue. Wearing a grey coat, he calmly announced that he had inspected the colour of the robe, and decided it was scarlet.

Joking about Dalton's colour blindness, a friend wrote in a letter to him, "I find by your accounts that you must have very imperfect ideas about the charms that constitute beauty in the female sex; I mean that rosy blush of the cheeks which you so much admire for being light blue..."

Having taken to private tutoring in order to meet his expenses, Dalton would charge each student ten guineas a year. He even taught at night, charging two shillings a lesson. "And yet in spite of all this," he wrote with characteristic humour, "I am not rich enough to retire."

As a further means to earning some money, Dalton wrote a book on grammar. The book was both interesting and original. In fact, it was a bit too original for it had listed, among other things, 'phenomenon' as a masculine noun and 'phenomena' as feminine!

Not many are aware that Dalton's earliest essays in science were published in *The Gentleman's Diary* and *The Ladies Diary*, to which he was a regular contributor!

Dalton was also the author of a series of essays on his meteorological investigations. In his preface he wrote that he had not relied on other books but merely on his own observations. However, soon after publication of his

book, he discovered that a French scientist had anticipated some of his conclusions. This drew a ready smile from him, with the comment: "I am delighted that two people, utterly unknown to each other, have arrived independently at the same knowledge."

When Dalton met Sir Humphrey Davy for the first time, he remarked, "The principal failing in his character as a philosopher is that he does not smoke."

With the publication of his atomic theory, Dalton became one of the most famous men in Europe. Among the many visitors who came to Manchester to catch a glimpse of this illustrious man, was the French savant M. Pelletier. This gentleman had imagined Dalton to be the wealthiest and the most conspicuous citizen of Manchester, occupying a handsome suite in a large university, like his own College de France or probably the Sorbonne. But, when he arrived in Manchester, he was jolted to find scarcely a clue to his whereabouts. After a long search, however, Pelletier was escorted to an alley and led into the back room of a shabby little house. He saw an elderly man peering over the shoulders of a young boy who was writing something on a slate. "Have I the honour of addressing Mr Dalton?" asked Pelletier.

"Yes," answered the old man. "Will you kindly sit down while I put this lad right about his arithmetic?"

One evening an acquaintance by the name of Ransome called on Dalton to find him sitting with a cat upon his knee, a newspaper at his elbow and a sculpture made of plaster at his side. Ransome picked up the sculpture and observed it carefully before remarking, "I am glad you have had this likeness made of your features, Mr Dalton. Posterity will never cease to be grateful for this thoughtfulness on your part."

"But it isn't my likeness you're looking at," replied Dalton amusedly. "It's Sir Isaac Newton's."

"What a striking resemblance!" exclaimed Ransome. "Indeed I should call it a miraculous resemblance!"

"No miracle at all," replied Dalton. "You see, my friend, it was the same mind that moulded the features for us both."

Dalton had resigned from Manchester College. One morning, he was walking on a street that passed by the house of the clergyman Rev. Johns. His wife was standing by the window and Dalton came over to greet her.

"Mr Dalton," she said, "how is it that you so seldom come to see us?"

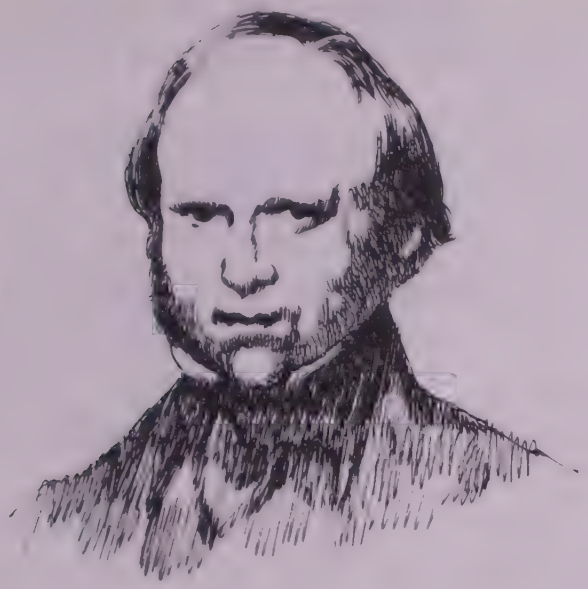
"Why, I don't know," replied Dalton. "But I have a mind to come and live with you." He then proceeded to eventually stay at their house for almost thirty years!

When the years went by and Dalton remained unmarried, his friends began to inquire if he had ever thought of taking a wife. "I haven't the time," he told them. "My head is full of triangles, chemical processes and electrical experiments to think of any such nonsense."

Dalton's name was known in all the science academies of the world. One of these decided to erect a statue of his in his honour. When completed and shown to him, he remarked, while gazing at it, "That is the great chemist Dalton. I am only the hollow nonentity of a man."

DARWIN, CHARLES ROBERT
Naturalist (1809-1882)

This British naturalist revolutionised the understanding of life by his demonstration of evolution by natural selection. His theory showed that all living beings, human beings included, are products of a process of gradual evolution from more primitive forms. Darwin's studies in science began with a reluctant stint at studying medicine at Edinburgh. Two years later, he was sent to Christ's College in Cambridge to prepare for Holy Orders in the Church of England as the last resort. This is where he became acquainted with the Cambridge scientists who exerted great influence on him and rekindled his self-



esteem. After graduating in 1831, he was recommended by John Henselow, a professor of botany, tc be an unpaid apprentice on the *H.M.S. Beagle*. The voyage was a turning point in the young Darwin's life. The observations he made while on this trip later provided the basis for his Theory of Evolution.

Darwin had been working on *The Origin of Species*, for twenty years, before it was ready for publication. As he was about to release his thesis, a strange coincidence took place. Quite innocent of the fact that Darwin was ready with a thesis on the subject, his friend in Malaya, Alfred Russel Wallace, sent him an original paper on the same subject, with a request to be introduced to the world as the originator of a new theory of evolution. Darwin decided to recommend his friend's thesis by abandoning his own. He said, "I would far rather burn my whole book than that he or any man should think that I had behaved in a paltry spirit." It was finally decided that it could be introduced as a joint work by the two friends. When Wallace found out, he was quick to outdo Darwin's generosity by admitting that the singular credit of discovering the origin of species belonged to Darwin. And thus ended one of the most remarkable controversies in

history—one in which each of the opponents tried to advance the interests of the other at the expense of his own glory.

Charles Darwin was doubtful of the success of *The Origin of Species* before its publication. While preparing its final copy for the press, he wrote to John Murray, the publisher: "I feel bound for your sake and my own, to say in the clearest terms, that if, after looking over part of my manuscript, you do not think it likely to have remunerative sale, I completely and explicitly free you from your offer."

Charles Darwin had his own typical method of collecting information. He first circulated typed questionnaires, whose answers enabled him to know who possessed the information he sought. After finding these individuals, he wrote letter after letters to them with the lines, 'If it would not cause you too much trouble...' or 'pray add to your kindness...' or 'I fear that you will think that you have fallen on a most troublesome petitioner', etc.

Even as a child Darwin had an acute sense of observation that did not falter even when he was in great danger. One day while he was walking on the ramparts of the Shrewsbury fort, absorbed as usual in his thoughts, he suddenly found himself in mid-air having absentmindedly stepped off a rather high parapet wall. On recovering from his brush with death, he made the following observation: "The number of thoughts which passed through my head during this very short but sudden and unexpected fall was astonishing...all of which seemed hardly compatible with what physiologists have stated about each thought requiring an appreciable amount of time."

It took a long time before Darwin's father, an illustrious physician and doctor, recognised his son's genius. He considered young Charles a good-for-nothing loafer, whose sole aim in life was "to mess up the house

with his everlasting rubbish". To put some "old-fashioned common sense" into his head, Dr Darwin sent his son to a classical school. However, Charles had other plans. Paying no attention to his teachers, he fixed up a secret laboratory in the garden. The teachers labelled him 'deranged' and the students nicknamed him 'gas'. The Headmaster repeatedly called him a 'thoroughly useless creature' and his father finally had him removed from the school in sheer disgust!

Darwin's masterpiece on the ancestry of the human race, a book he compiled soon after returning from his voyage on the *Beagle*, reads more like a romantic adventure than a scientific treatise. Darwin hated esoteric verbiage and always strove to make everything clear and simple. "It is a golden rule," he said, "to always use, if possible, a short old Saxon word. Such a sentence as 'so purely dependent is the incipient plant on the specific morphological tendency' does not sound to my ears like good mother English; it wants translating. I think too much pains cannot be taken in making the style transparently clear and throwing eloquence to dogs."

When Charles Darwin was visiting the countryhouse of a friend, the two boys of the family decided to play a joke on him. So they caught a butterfly, a grasshopper, a beetle and a centipede, and out of these creatures created a strange composite insect by gluing the various parts carefully together. Then, with their new hybrid bug kept in a box, they knocked at Darwin's door.

"We caught this bug in a field," they said. "Can you tell us what kind of bug it is, Sir?"

Darwin looked at the bug and then at the boys, smiling ever so slightly. "Did you notice whether it hummed when you caught it, boys?"

"Yes," they promptly replied, nudging one another.

"Then," said Darwin, "it's a humbug."

One day Prime Minister Gladstone called upon

Darwin. After he had left, Darwin remarked, "Mr Gladstone seemed to be quite unaware that he was a great man, and talked to me as if he were an ordinary person like myself."

When this statement of Darwin's was reported to Gladstone, the latter replied, "My feeling towards Mr Darwin was exactly the same as Mr Darwin's towards me."

If out of all the kindly qualities that Darwin possessed, one were to choose that which would be the keynote of his character, it was his thoughtfulness for others. Never would he allow himself to depend on others for fear of inconveniencing them—a quality he retained till the end.

Shortly before he died at the age of seventy-three, he visited London for the last time. Just as he was about to enter the house of a friend, Darwin was seized with a fainting spell. The friend was not at home, but the butler, on noticing Darwin's condition, urged him to come inside. But Darwin replied, "Please don't trouble yourself. I shall find a cab to take me home." So saying, the considerate old scientist walked away.

DAVY, SIR HUMPHREY
Chemist (1778-1829)

Davy, the British chemist, isolated sodium and potassium and established the elementary nature of chlorine and iodine, besides inventing the miner's lamp.

Sir Humphrey Davy, the doyen of British scientists, had a miserable schooling. There was a particularly obnoxious master who delighted in using the cane on young Davy. It was a very common sight, this thin boy receiving a chastisement from the master on his rear in full view of the class. What must have made this recurring incident particularly hilarious to the spectators was the teacher singing aloud in tune with the movement of his cane:

'Now Master Davy, Now Sir I have ye,

No one shall save ye, Good Master Davy.'

Davy was once interested in studying the effects of nitrous oxide (laughing gas) on himself. He expressed the results of this experiment on himself in a letter to a friend as follows: "Davy, of whom it was said by Coleridge that if he had not been the first chemist, he would have been the first poet of his age, tried to investigate whether inhalation of the gas enhanced his poetic qualities. It is said that it only gave his poems a poor quality."

Davy once collected a group of friends in order to subject them to the effects of nitrous oxide. The consequence was more than hilarious. One member of the party started dancing around another in a fit of laughter. A particularly enterprising young man hit Davy ferociously on the head. Another member, this time a lady, became so exhilarated by the gas that she bounded out of the house, jumped over a large dog in the compound and leapt over the railing with astonishing speed and alacrity. It was with great effort that someone could finally capture her without any further damage.

Writing about the effects of his experience with nitrous oxide, Davy was to confess, "...it raised my pulse upwards by twenty strokes and made me dance about the laboratory like a madman."

Davy's scientific career began with his first extended work that attempted to prove wrong Lavoisier's theory on heat and light. However, his publication brought him plenty of scorn and ridicule and since then Davy became wary of speculation in public. In 1798, he joined the newly established Medical Pneumatic Institution. Here he published his classic work, *Researches, Chemical & Philosophical, Chiefly Concerning Nitrous Oxide*, which established his scientific reputation. Around 1800, he began a study of Volta's invention of the Voltaic pile, which had made electric current available for the first time. Davy was to establish the electrical nature of chemical affinity that was to become the basis for the work of his protege

Michael Faraday. Davy isolated the metals sodium and potassium in 1808, and announced the discovery of iodine in 1813. He was knighted and married in 1812. His scientific work thereafter grew sporadic and his most important work was the invention of the miner's lamp.

DIRAC, PAUL ADRIAN MAURICE
Physicist (1902-1984)

This British theoretical physicist made fundamental contributions to quantum mechanics. He was awarded a share of the 1933 Nobel Prize for physics for his discovery of new forms of atomic theory. While at Cambridge, Dirac was initiated into the emerging theories of quantum physics when he chanced to attend a lecture by the noted physicist Werner Heisenberg. This was in 1925. Within three years, Dirac had applied the techniques of relativistic mechanics to quantum theory. His equations revealed a curious property that was to change the science of quantum physics in a way that had never been predicted—they included negative energy states that led him to predict that the electron has a counterpart in another positively charged 'anti-particle', which he called the *positron*. This

particle was discovered in 1933. Dirac also pioneered the quantum theory of radiation and worked with Fermi on the Fermi-Dirac statistical theory. His book, *The Principles of Quantum Physics*, which he wrote in 1930, is considered by physicists as a classic on the subject.

During the question hour following Dirac's lecture at the University of Toronto, somebody in the audience asked, "Professor Dirac, I do not understand how you derived the formula on the top left side of the blackboard."

"This is not a question," Dirac responded. "It is a statement. Next question, please."

Once Dirac was watching Russian physicist Peter Kapitza's wife knitting while he was at their home. A couple of hours after he had left, he was back at their door again, very excited. "You know, Anya," he said, "watching the way you were making this sweater, I got interested in the topological aspect of the problem. I found that there is another way of doing what you were doing. Moreover, it appears that these are the only two ways of doing it. One is the method you were using and the other one is like this..." So saying, he demonstrated the other way, using his long thin fingers excitedly. Anya stayed calm and unmoved by this 'other way'. After Dirac had finished his demonstration, she quietly informed him that this was a rather well-known technique, called 'purling', which had been known to women for a considerable time!

Once a student asked Dirac, "What is it that tells you that your equations are mathematically correct?"

"I check if they are beautiful," replied Dirac. "If they are, then they must be correct!"

Colleen Taylor Sen who was present at one of the conferences attended by Dirac has this to say on him, "I was attending a conference on energy in Fort Lauderdale and Dirac was one of the several Nobel laureates invited to grace the occasion. He was pointed out to me at a large and noisy cocktail reception—a frail elderly man

standing all alone and apparently ignored by the other guests. When I suggested to a colleague that we go and talk to him, he replied, 'I couldn't. That would be like talking with God.' But, not being a physicist, I suffered no such reservations and entered into conversation with Dirac about G.H. Hardy, his contemporary at Cambridge, whose *Mathematician's Apology* I had just finished reading. Dirac told me that Hardy had a picture of Bradman in his study and asked me if I knew who he was. When I identified him as a cricket player, Dirac was clearly surprised that a non-Englishman knew something about cricket and proceeded to describe Hardy's fondness for cricket and how he used to bowl on the lawns of Cambridge. He then reminisced about other Cambridge contemporaries, including Wittgenstein, of whom he commented, 'Awful fellow. Never stopped talking.' Dirac actually became quite effusive, and talked with me for an hour or so."

DUMAS, J.B.A.
French chemist (1800-1884)

Dumas devoted his research work in chemistry to the understanding of chemical phenomena and by teaching to students, propagated his love for the subject among others. Dumas, when seventy-nine, once said, "I have seen many phases of life, I have moved in imperial circles, I have been Minister of State but if I had to live my life again, I would always remain in my laboratory, for the greatest joy of my life has been to accomplish original scientific work, and, next to that, to lecture to a set of intelligent students."

One of his students was Louis Pasteur. As a young student of twenty, Pasteur has written: "I attend at Sorbonne the lectures of Dumas, a celebrated chemist. You cannot imagine what a crowd of people come to attend these lectures. The room is immense, and always

quite full. We have to be there half an hour before the time to get a good place, as you would in a theatre...six or seven hundred people are always gathered there."

EDDINGTON, SIR ARTHUR STANLEY
Astronomer-physicist (1882-1944)

Eddington was the first British astronomer and physicist to explain the dynamics of transport of energy from the interior of a star to its surface. Eddington became Plunian Professor of Astronomy at Cambridge at the age of twenty-five, and in the following year, became Director of the Cambridge observatory, holding both these positions until his death. He was knighted in 1930 and awarded the Order of Merit in 1938. His three great scientific publications are: *Stellar Movements and the Structure of the Universe* (1914), *The Internal Constitution of the Stars* (1926) and *The Mathematical Theory of Relativity* (1923). He was a prolific writer and also published many popular works that included *Space, Time & Gravitation, Stars & Atoms* and the more philosophical, *The Nature of the Physical World* and *Philosophy of Physical Science*. Eddington is also remembered for his attempts at observation of the deflection of starlight around the sun in 1919. Later he attempted to unify the theory of relativity and quantum theory and to derive values of physical constants, such as the gravitational constant and the mass of the electron, entirely by theoretical means.

Once Eddington was coming out of the Conference Hall with a scientist friend, who remarked, "Sir, we understand there are only three persons who understand Einstein's relativity theory fully."

Eddington did not reply but looked pensive. The scientist friend continued, "Sir, for a well-deserved praise, one need not be modest."

Eddington then replied, "I am just wondering who is the third person!"

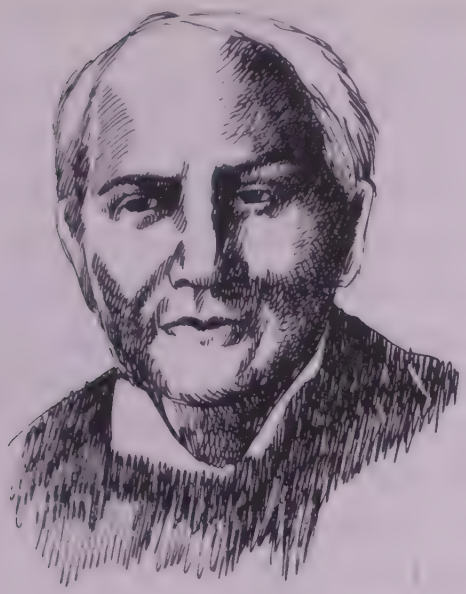
Eddington, a staunch idealist, once told the biologist Haldane, a committed materialist, that "all materialists must think of their wives as differential equations." Haldane then took up the matter seriously with a physicist friend. The latter (a happily married man) told him that he would not love his wife if he did not believe she was a differential equation. When a confused Haldane asked him to explain, the friend replied that he loved his wife because she had a 'definite character' unlike a differential equation, which "renders her conduct intelligible even when it's surprising."

In the course of his now legendary lecture, on 'Stars and Atoms' at the Oxford Union in 1926, Eddington was displaying a slide of the track left behind by an alpha particle in a cloud chamber. A technician had accidentally left a thumb mark on the plate, as clearly visible as the track itself. Unperturbed, Eddinton went on to explain that the photograph was not of the alpha particle itself, but of the track it left behind, similar to the thumb mark left behind by the thumb. This was a marvellous example of Eddington's quick-wittedness, and even the great J.C. Growther, who was in the audience, was convinced that the thumb mark was intentional.

Once when asked, how many people Eddington thought would understand what he was writing, there was a long pause before his reply, "Seven." Nobody could quite tell who these privileged seven were.

EDISON, THOMAS ALVA
Inventor-industrialist (1847-1931)

American inventor and pioneer industrialist, the self-educated Edison achieved the status of a folk-hero by becoming one of the really great inventors of all time with more than a thousand American patents to his name. Three of his inventions—the phonograph, the electric bulb and the moving picture camera—went on to completely



transform societies all around the world. Edison learnt telegraphy at the age of sixteen, and roamed the mid-West for the next four years as an operator, dreaming of becoming an inventor. His first invention, an electric vote recorder, was patented in 1869, but it didn't sell. He then made certain improvements on a stock ticker and had them patented, but that didn't sell either. He then decided that he would never attempt to invent anything that did not have a commercial demand for it. This was to become his motto for the rest of his life. From these beginnings, he went on to become one of the greatest inventors of all time.

Thomas Edison once found himself in a boring social gathering. He decided to slip out and had almost reached the door when his host caught up with him and said, "It is a great honour that you are with us today. And by the way what are you working on now?"

Pat came the reply, "On my exit!"

He once remarked, while referring to a newspaper article that called him a scientist, "That's wrong, I am not a scientist. I am an inventor. Faraday was a scientist. He didn't work for money, he said he hadn't the time. But I do. I measure everything I do by the size of a silver

dollar. If it doesn't come up to that standard, then I know it's no good."

Born into a family that had gone bankrupt, the young Edison worked as a newspaper and candy salesman on the Grand Trunk Railway when he was twelve years old. His interest in science however continued unabated and a small laboratory that he had made in his cellar, was shifted to the baggage car of the train, where he worked when he was not required to work as salesman. All his reading was carried out in the Public Library in Detroit where he had to wait it out for the return journey!

His fortune changed when he arrived penniless in New York in 1869. He visited Law's Gold Indicator Company, where he was asked to study the instruments that transmitted changes in gold prices to subscribers and to sleep in the battery room. His big chance came one day when the central transmitter broke down. Edison was quick to spot the trouble and had the device running within two hours. He found employment for US$ 300. A year later, he received US$ 40,000 from the management for improvements on his stock-ticker invention.

Thomas Edison was once working on his electric lamp when a New York journalist Michels approached him about the launching of a new science journal called *Science*. Edison immediately agreed to become a financial backer and kept pouring money into the magazine. After having invested close to US$ 10,000, when the magazine showed no signs of fetching any returns, he pulled out of it. Significantly, when *Science* carried an article on him, no mention was made of the financial support he had extended.

One day Henry Ford and Thomas Edison called on Luther Burbank, who asked them to write their names in his guest register. It had three columns: one for 'home address', the second for 'occupation' and the third one was entitled 'interested in'. Edison quickly filled in the first two, and in the final column wrote, 'everything'!

Mary Stilwell, who had joined the Edison laboratories, was a capable and valuable assistant. One day, in the midst of a new experiment, Edison stopped and looked at her, "Mary...!"

"Well, what is it Al?" asked Mary.

Edison took out a coin from his pocket and tapped out a message in Morse code on the edge of his desk:

HAVE BEEN THINKING MUCH ABOUT YOU LATELY STOP WILL YOU MARRY ME QUERY.

Mary blushed. Then she tapped out the answer:

THAT WOULD MAKE ME VERY HAPPY.

Edison had a beautiful summer residence and one day he was showing his guests around, pointing out all the labour-saving devices on the premises. Turning back towards the house, it was necessary to pass through a turnstile which led on to the main path. The guests soon discovered that it took considerable force to get through. "Mr Edison," asked one of the guests. "How is it that with all these wonderful modern things around, you still maintain such a heavy turnstile?"

Said Edison, his eyes full of merriment, "Well, you see, everyone who pushes the turnstile around, pumps eight gallons of water into the tank on my roof!"

Edison had been involved in one of the processes of sub-dividing an electric current. A patent suit arose subsequently over the matter. The famous English physicist Tyndall was called upon to testify. He mentioned that he had followed the same course taken by Edison and had hesitated before the final step that now seemed so childishly clear.

One of the attorneys demanded, "If the next step was so obvious, why did you not take it?"

"Because," replied Tyndall, "I am not Thomas Alva Edison."

"Results!" exclaimed Edison to an assistant dismayed by the bewildering number of his failures. "Results? Why man, I have gotten a lot of results. I know fifty thousand things that won't work."

EHRLICH PAUL
Bacteriologist (1854-1915)

Ehrlich, the German bacteriologist and immunologist, shared the Nobel Prize for medicine in 1908 for his contributions to the understanding of immunity. He did pioneering work in the fields of haematology and chemotherapy. He was the first to demonstrate the staining properties of the *tubercle bacillus*. In 1890, Ehrlich was invited by the German bacteriologist Robert Koch to join the staff of the newly created Institute for Infectious Diseases in Berlin. There he perfected a method for standardising the dose strength for the newly developed diphtheria antitoxin, thus effecting one of the first applications of bacteriology in medicine. Later he turned to studies in chemotherapy, which led him to discover salvarsan, a 'magic bullet', against syphilis micro-organisms, that was first used successfully in 1910.

As a schoolboy of fourteen, Paul Ehrlich, when asked to write on the rhetorical and romantic theme, 'Life—a Dream', wrote: "Life may well be a dream, but dreams are, in fact, a chemical process, a kind of cerebral phosphorescence and therefore have none of the romantic quality that those who know nothing about chemistry might expect." This essay upset his teachers sufficiently to fail him, despite all his innocent protests.

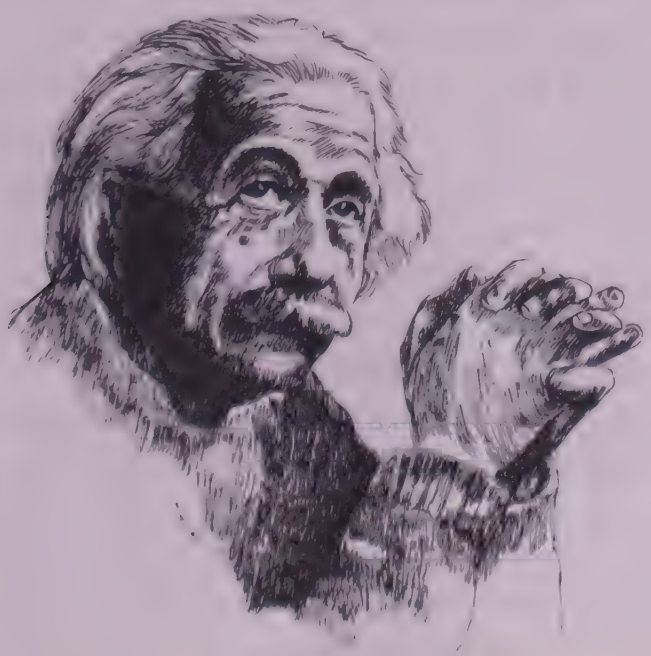
As a young student, Paul Ehrlich was once deeply engrossed in his work at his bench in Breslan University laboratory, when his professor, accompanied by a stranger, came in. The professor pointed to Ehrlich and said, "That is little Ehrlich, who is very good at staining, but will never pass his examination."

'Little' Ehrlich not only passed his examination, but after some years, was to collaborate with the same stranger in a work of great significance. The stranger was none other than Robert Koch.

EINSTEIN, ALBERT
Physicist (1879-1955)

One of the greatest theoretical physicists of all time, Einstein is best known as the creator of the Theory of Relativity, although the Nobel Prize he was awarded was for his work on the photoelectric effect. In 1905, he published four invaluable papers in a physics journal. Later he revealed that it took him only five weeks to write his first paper on relativity, in between his work as a clerk. In 1919, he published his Theory of General Relativity, that was confirmed experimentally in 1921. He was awarded the Nobel Prize, the same year.

Einstein was fortunately lecturing abroad in California when Hitler came to power. He was soon appointed to a permanent post in the newly founded Institute for Advanced Studies in Princeton. He became an American citizen in 1941. In his later years, Einstein was increasingly concerned with the social consequences of science. After the war ended, he worked prominently as a pacificist. Einstein was invited to become the President of Israel in 1952, but refused as he wished to keep away from politics. He died in Princeton three years later.



Einstein had an unhappy schooling and was always in trouble with his teachers. One day, one of them summoned him and said, "Albert, I must insist that you stop asking questions in my classes. I have no answers for them and the students are losing their respect for me. It seems to me that, should you decide to leave this school, it might be a very good idea."

An extremely poor student, Einstein encountered great difficulty in finding a job. He was finally appointed as a clerk in the Patents Office at Bern, where his job was to put applications for patents in a clear form. That was the year 1902. Einstein was rather happy at his clerical job in the Patents Office since he could easily finish a whole day's work in two or three hours leaving him time for other work. Whenever anyone walked in, he would nonchalantly and with an air of efficiency, slip his scribblings, usually equations, into a file in his desk drawer!

Einstein's proposal to Mileva Maria began by his saying, "I have been trying to solve the problem of space and time..." Although why he married her was a mystery as he was unhappy from the very beginning. Even after earning recognition for his Theory of Relativity, his domestic life was pathetic. Said one of his colleagues, who visited him at his house in Bern, "The door of the apartment was open to allow the floor, which had just been scrubbed, as well as the washing hung up in the hall, to dry. I entered Einstein's room. With one hand, he was calmly rocking a cradle; in his mouth he had a very bad cigar, and in the other hand, an open book. And the stove was smoking horribly."

A newspaper artist once made a hasty sketch of Einstein aboard a ship. When it was ready, he showed it to Einstein and demanded an autograph. Einstein hesitated. He particularly disliked these absurd sketches, but loved to write comic verse and could not resist the idea that then occurred to him. Borrowing the reporter's fountain

pen, he wrote, "This fat, well-sated pig you see, Professor Einstein purports to be."

The queen of Belgium once invited Einstein to visit her. Little did the scientist think that important officials would be waiting at the station to receive him. Alighting quietly from the train, he proceeded on foot with a suitcase in one hand and a violin, in the other. The dignitaries in the meanwhile had driven back to the palace. Soon after, a grey haired man appeared tramping up the road. After receiving him, the Queen asked, "Why didn't you use the car I sent for you, Herr Doktor?"

The distinguished guest gave a gentle smile and said, "It was a very pleasant walk, Your Majesty."

Once Einstein climbed a ladder to change the picture on the wall. Lost in a train of thoughts, his foot slipped and he fell to the floor. Quickly recovering from the fall, he took out a paper and pen and began working out the causes of the fall. Like the fall of the apple in Newton's garden, this incident led Einstein to restructure the Theory of Gravitation.

His theory of bending of light had been proved right to the exact decimal point, during the eclipse of 1919. When Einstein received the photographs, he viewed them with a twinkle in his eyes. "Now that my Theory of Relativity has been proved true," he chuckled, "Germany will claim me as a German and France will declare that I am a citizen of the world. Had my theory been proved false, France would have said that I was German and Germany would have declared that I was a Jew."

On being asked to explain the Theory of Relativity, Einstein said, "When a man sits with a pretty girl for an hour, it seems like a minute. But let him sit on a hot stove for a minute and it will seem like more than an hour. That is relativity."

One evening a young lady introduced her fiance to the pastor of her church. The next day, the pastor met the lady and gently took her aside. "I approve of your young

man in every respect save one," he told her. "He lacks a sense of humour. I asked him to explain to me Einstein's Theory of Relativity and he actually tried to do it."

George Gershwin, the noted American composer, was once discussing the Einsteinian theory. "Imagine," began George, "working for twenty years on an idea and then being able to write it down in three pages!"

Retorted the senior Gershwin, "It was probably in very small print."

When the Nazis found out that Einstein was not going to return home from the USA, they were enraged and they plundered and ransacked his house, confiscating all his bank documents. They also put a prize of US$ 1,000 on Einstein's head. When he heard of this, Einstein remarked, "I did not know it was worth so much."

Once, while riding a street-car in Berlin, Einstein told the conductor that he had not given back the right change. The conductor counted the change again and finding it to be correct, handed it back, saying, "The trouble with you is you don't know figures."

While he was living in Berlin, the English painter and writer Sir William Rothenstein did Einstein's portrait. During the sittings, the artist found a 'solemn looking individual' quietly sitting in the corner of the room and occasionally nodding or shaking his head in response to what Einstein said to him. At the end of the sittings, Sir William asked the scientist about the man's identity and was told, "That's my mathematician. He examines problems which I put before him and checks their validity. You see, I am not a good mathematician myself."

Jacob Epstein, the sculptor, once narrated, "When I was doing Albert Einstein's bust, he had many jibes at the Nazi professors, one hundred of whom had condemned his Theory of Relativity in a new book. 'Were I wrong,' Einstein had remarked, 'one professor would have been enough'."

When the Einsteins arrived in America, reporters

swarmed and crowds milled around them as their ship berthed. Bits of paper and streamers became tangled in Einstein's hair but he took no notice, as he answered the questions fired at him. "How do you like the States?"

"I have not seen it yet."

"How long will you remain?"

"I do not know yet."

"Can you explain the Theory of Relativity in one sentence?"

"No."

"Why are women so excited about the Theory of Relativity?" (Laughter).

"Because women like a new fashion every year and this year it is the Theory of Relativity."

Another time he was asked, "Do you think a college education is really necessary? Cannot all information be found in books?"

To which Einstein replied, "I myself do not burden my memory with simple facts that can be looked up in text-books. But the true purpose of education is to train the mind to think. For that reason it is priceless."

Churchill Eisenhart, son of the former Dean of Princeton University, tells of a telephone call to the Dean's office. The caller said, "Perhaps you could direct me to where Dr Einstein lives." Since it had been agreed that Einstein was to be protected from inquisitive callers, the request was politely refused. The voice on the other end dropped to a whisper and continued, "Please do not tell anybody, but I am on my way home and have forgotten where my house is."

Einstein regularly went on lecture tours. Once his second wife Elsa carefully packed his suitcase and warned him, "The black suit is to be worn on the evening you make your speech. Don't forget. Put on the clean shirt, tie and please, please, the socks!" He dutifully nodded.

On his return, Elsa found the suitcase untouched. Einstein smiled ruefully, "I guess I forgot...but then, they

came to hear what I had to say and not to see whether I was fashionably dressed, isn't that so?"

Once after a successful talk in Prague, Einstein was asked to say a few words to the specially invited group. He answered, "It would perhaps be more understandable and more enjoyable if I were to play for you instead." He brought out his violin and proceeded to play Mozart sonatas to a small and highly appreciative audience.

While he was in Japan, he was greatly impressed by the audience sitting motionless for hours, listening in a language they did not fathom,about a subject they did not understand. After one lecture had dragged on for over four hours, Einstein resolved to make his next one shorter, out of pity for his patient listeners. That evening, his hosts were very quiet and reproached him, "The people of our city feel insulted. Your lectures in the other cities lasted four hours; to us you spoke only for two hours!"

A socialite, who was determined to entertain Albert Einstein, found to her dismay that he had engagements for almost the whole of the week. "What a shame," she said. "But may be, on Friday evening you're free."

"On Friday evening," Einstein patiently told her, "I've promised to go to the observatory with my friend Dr Michelson to look through the telescope."

The lady, however, persisted. "But you know how it rains in California, and it may rain on Friday evening. Then, as you won't be able to see the stars, you can surely accept my invitation."

Einstein smiled broadly. "It won't rain," he said positively. "Michelson has arranged for that!"

The Badehalle was packed for a discussion on relativity. Lenard began speaking first and, in the words of Dr Freidrich Dessaner, who was sitting on Einstein's left, "He (Einstein) wanted to take notes, but as one would expect of him, he had no pencil. He asked for mine so that he could reply clearly and convincingly to Lenard's

objections. As a minor joke, Einstein has my pencil to this day. At least he never returned it to me; what has come from it is probably more intelligent than it would have been if I had got it back."

Though he never had any desire whatsoever for awards or recognition, Einstein never doubted that he would eventually be given one. He went so far as to include the anticipated Nobel honorarium in the divorce settlement he agreed to in 1919. The award came two years later!

A little schoolgirl was having some difficulty with her homework in arithmetic. She had heard that, close to her house, there stayed a very famous mathematician who was also a very good man. She went to him and asked him to help in the homework. The old man was very helpful and explained everything patiently. "It was easier to understand then than when our teacher explained it in school," said the girl to her mother later. This old 'mathematician' happened to be none other than Einstein.

When the child's mother heard of this, she immediately went over to his house to apologise for the inconvenience. But the old man who welcomed her in, replied, "You don't have to apologise. I have certainly learnt more from the conversation with the child than she did from me."

The so-called Society of Patriotic Women lodged a protest with the American government against Einstein's entry into America as a pacificist, claiming that he nursed communist aspirations. In a letter to the American consulate in Berlin, Einstein wrote: "I have never been repulsed with such energy by the members of the fair sex at my first advance, or if it ever happened, it was never by so many at the same time. But are not these vigilant citizens perfectly right? Why open their gates to an individual who devours capitalists with the same appetite as the Minotaur in Crete who devoured the ravishing Greek virgins, and to make the matter worse was vile enough

to reject any idea of war with the exception of the inevitable war with his own wife? In consequence, do not ignore the advice of your patriotic women. Remember that Rome was once saved by the cackling of a few zealous geese."

Once while sailing, Einstein ran aground on a sandbank where he was later found by a boy in a boat. "What is the matter, mister?" called out the boy.

"It's too shallow for me to get off until the tide comes in," replied Einstein.

"Shall I get a bigger boat than mine to shove you off? The tide won't be in for about four hours," said the boy.

"No, thank you," was Einstein's reply.

"And what will you do with yourself for four hours?"

Einstein calmly replied, "I shall have a nice time—I shall sit quietly and think."

The Einsteins had become weary of all the fuss over them by the time they were on the last lap of their travel abroad. Complained Elsa, "It's easy enough for you to be patient. You are a famous man. If you make a mistake in etiquette, it is overlooked. But the newspapers don't leave me alone. Just because I am near-sighted, they reported that last night I ate the green leaves of the flowers at my plate instead of my salad."

A wealthy industrialist once sent a 'Guarnerius' violin valued at $ 30,000, which was duly returned with the modest note: "This valuable instrument should be played by a true artist. Please forgive me, I am used to my old violin."

Einstein was certainly, in a way, the last of the classical physicists. This most radical of thinkers, who with his Theory of Relativity completely transformed earlier conceptions of space, time and matter, could never reconcile himself to the new quantum theory, objecting to its emphasis on probability. Writing in a letter to Born, Einstein expressed his feelings strongly: "I find the idea

quite intolerable that an electron exposed to radiation should choose of its own free will, not only its moment to jump off, but also its direction. In that case, I would rather be a cobbler or even an employee in a gaming house than a physicist."

Einstein was deep in discussion about the merging theory of quantum physics with Niels Bohr when they reached a point where Einstein was cornered. He exclaimed, "God does not play dice."

Bohr, who was equally upset, yelled back, "Stop telling God what to do."

Asked one day for a mathematical formula for success in life, Einstein gave the following one, "If A is success in life, then the formula is A equals X plus Y plus Z, X being work and Y being play.

"And what is Z?" he was promptly asked.

"Keeping your mouth shut," was the reply.

The *Saturday Review* once posed the question, 'What have I learned?' to a few distinguished persons.

Quite different from all the others, Einstein had three characteristic answers: "*One*, pay close attention to the curiosities of a child; this is where the search for knowledge is freshest and most valuable. *Two*, the advent of nuclear energy has changed everything about the world except our way of looking at it. And *three*, my ideas caused people to re-examine Newtonian physics; it is inevitable that my own ideas will be re-examined and supplanted. If they are not, there will have been a great failure somewhere."

Once the Mark Twain Society offered Einstein the post of honorary vice-president. When he found out that the same society had once offered a similar honour to Mussolini, he flatly rejected it.

Einstein was once offered a hand-pulled rickshaw to take him through some narrow streets, but he firmly refused, "Never would I use another human being as an animal and permit him to carry me about."

Disgusted with the state of world affairs and the growing violence, Einstein went on a trip to the Orient. When he was in Japan, he refused to participate in any of the ceremonies that had been put up in his honour. Instead, he spent a lot of time with the Japanese children. He accepted the drawings they drew for him and listened joyously to their talk. "In the children lies the hope of the world," he said. "They must never be brought up to hate. They must never abuse the hard-won achievements of the human race." And he turned to the litle ones and said, "Let us hope that your generation will put mine to shame."

At the height of his fame, Einstein's name was on eveyone's lips. Simple and unassuming, he disliked the adulation and adoration showered upon him. He would often exclaim vexedly, "Everybody talks about me and nobody understands me!"

Gilbert Murray once caught sight of Einstein sitting with a far-away look on his face. The far-away thought behind the far-away look was evidently a happy one, for at that moment, his countenance assumed a serene expression. "Dr Einstein, do tell me what you are thinking," pleaded Murray.

"I am thinking," replied Einstein, "that after all, this is a very small star."

ENDERS, JOHN FRANKLIN
Microbiologist (1897-1985)

This American virologist shared the 1954 Nobel Prize in medicine with two other Americans—Thomas Weller and Fredrick Robbins—for their discovery of the ability of the polio viruses to grow in cultures of different types of tissues. This discovery enabled scientists to grow the polio virus in quantities that made it possible for the manufacture of the first polio vaccine. After completing his doctorate on the condition of extreme hypersensitivity, he joined Harvard University and worked on the growth of

herpes viruses. In 1948, he and his co-workers turned to the polio virus. At that time it was generally believed that the poliomyelitis virus could only live in nerve cells. Enders doubted it and successfully proved that it was not neurotropic, and through painstaking research, observed the growth of the virus in other tissue cultures. Later in 1954, he also isolated the measles virus, which made it possible for developing the measles vaccine.

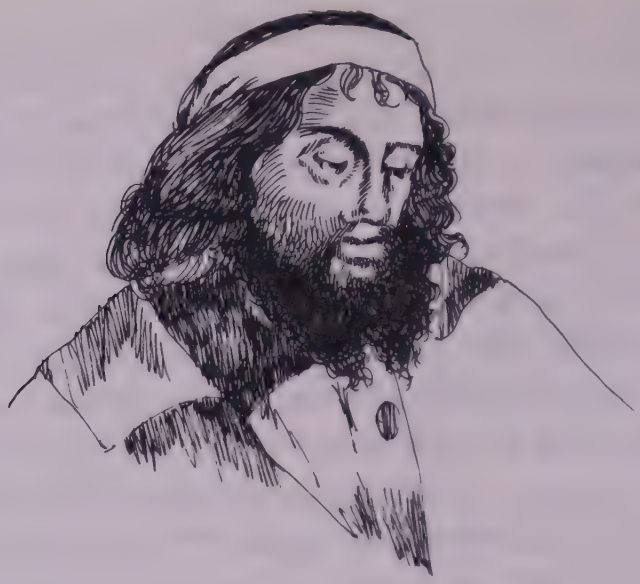
Enders was a banker's son, who served as a fighter pilot in the First World War. After the war, he went to Yale where he received his graduation in English in 1919. After that he became a real estate businessman! He then went back to study at Harvard for graduation in English literature. In 1930 he switched over to microbiology, where he received his doctorate in bacteriology and immunology.

When Enders, Weller and Robbins, who jointly won the Nobel Prize for medicine in 1954, were asked what they felt about their success, each one of them responded differently. The reaction of Robbins, the youngest of the three, was immediate. "It was all very simple," he replied. The middle-aged Weller called it a "fortuitous circumstance". Enders, the oldest of the lot, had a faraway look in his eyes as he softly muttered, "I guess we were foolish for so long in the beginning..."

EUCLID

Mathematician (365 B.C.-300 B.C.)

The Greek mathematician wrote the book, *Elements*, which is the oldest Greek mathematical work to have survived. His work on geometry was regarded as a model of logical reasoning until the 20th century. Very little is known about the life of Euclid and he is often confused with Euclid of Megara, the Socratic philosopher. There is a school of thought which believes that Euclid was taught by Plato's successors in Athens and that he taught in



Alexandria. The first printed version of *Elements* appeared in 1482, in Latin. The first English translation was published in 1570. Among his other surviving works is *Optics*, in which Euclid wrote that the basis of vision is the emission of rays from the eyes that travel to the objects of sight.

When Euclid was told by his fellow-professors at Alexandria that there was no way of measuring the height of the great pyramid, he merely smiled. He then proceeded to measure it as follows: at the precise time when the length of his shadow was exactly equal to his height, he measured the length of the pyramid's shadow. "This, gentlemen, is the exact height of the great pyramid."

Ptolemy, the King of Alexandria, once expressed his impatience at the elaborate manner in which Euclid explained his theorems. "Isn't there," asked the King, "a shorter way of learning geometry than your method?"

"Sire," replied Euclid, "in our country, there are two kinds of roads—the hard road for the common people and the easy road for the royal family. But in geometry all must go the same way. There is no royal road to learning."

On occasions, the gentle and kindly Euclid could be quite sarcastic. Once during class, a student put to him a question just after he had learned his first theorem. "Can you tell me just what is the practical advantage in studying geometry?"

Upon hearing this, Euclid turned to his servant and said, "Give this gentleman some money; he cannot learn without money."

Shy and aloof, Euclid cared little for petty politics and military glory. A little before his death, he once said, "These things shall pass. But the designs of the heavenly stars shall remain eternally fixed."

FARADAY, MICHAEL

Physicist-chemist (1791-1867)

Faraday, the British physicist and chemist, discovered the relationship between electricity and magnetism, thus laying the foundations of a new world of electric power. He also created the science of electrochemistry and was the principal architect of the classical Field Theory that was subsequently developed by James Clerk Maxwell and Albert Einstein. Faraday's insights into experimental science made him one of the greatest experimental scientists of all time.

Faraday was born in a deeply religious family belonging to the orthodox Sandemanian sect, and his formal education was limited to the elements of reading and writing. His knowledge of mathematics was rudimentary in the least, but according to Faraday, it was precisely the lack of mathematical knowledge that allowed him to develop the Field Theory. In 1805, he became an apprentice to a bookseller and bookbinder. That is where he read all the books he wanted to. Faraday's interest in science was the result of reading an article on electricity in an article in an encyclopaedia. Before long, he had developed his first instrument—an electrostatic

generator out of old glass bottles.

Farday's scientific career began in 1813 as a laboratory assistant to Humphrey Davy (refer to anecdotes for details). In 1825, he succeeded Davy as Director of the laboratory. On 29 August 1831, he found that currents could be induced by making or breaking an electric circuit and its accompanying electromagnetic field, thus discovering electromagnetic induction. A few weeks later, he found that when he plunged a permanent magnet into a coil of wire, electric current was generated. This was the world's first generator. Two weeks later, he succeeded in getting a steady current by rotating a copper disc between permanent magnets, which was the world's first dynamo. Faraday was elected a member of the Royal Society in 1824, but declined further honours, including a knighthood and presidency of the society.

Michael Faraday was the son of an ordinary village blacksmith. As a child he showed no signs of his future genius, and spent most of his time 'watching sunsets'. A defect in his speech brought him ridicule and abuse from his teacher—an old maid who hated children. Once she decided to resort to blows and beckoned his brother Robert, who was in the same class, to her desk. She gave him a half-penny and ordered him to buy a cane announcing that she wanted to give Michael a public flogging. But Robert had other ideas. He chucked the coin out of the window and ran home to report the matter to his mother. Mrs Faraday decided to take both boys out of the school. That was the end of Michael Faraday's education!

Unable to make a living in the Surrey village of Newington Butts, Michael's father moved his family to London, in the hope of finding work. However, their fortunes remained very much the same. One of Michael Faraday's strongest memories of that time was about his weekly ration. It used to be a loaf of bread a week, which his mother allowed him to ration out for himself. Michael used to get the loaf on Monday, which he then carefully

divided into fourteen portions—two per day, one for breakfast and one for dinner. Reminiscing this, Faraday later mentioned that it was through this 'careful management', no doubt excellent training for a scientist, that he never went 'altogether hungry'.

While he apprenticed to a shopkeeper, one of the customers gave Faraday tickets to a series of lectures by the legendary Humphrey Davy, the then Director of the Royal Institution's laboratory. Faraday was so inspired by the lectures, he took careful notes, rewrote them in his fine hand and made use of his bookbinding training to bind them handsomely. He then sent these to Davy, asking for employment. Davy was greatly impressed but felt bound to consult his colleagues. Their advice was to "put him to wash bottles: if he is good for anything, he will do it directly; if he refuses, he is good for nothing." And so Faraday joined the Royal Institution as a janitor and from this he rose to become the Director of the institution!

Beginning his scientific career as a janitor, Faraday soon found himself being relied upon by Davy. He became a kind of lab assistant, sometimes taking active part in Davy's experiments. Some of the experiments they performed were risky and both of them sustained injuries. After one such particularly dangerous experiment, Faraday wrote to his friend Benjamin Abbot: "...The most terrible thing was...when a compound of chlorine and azote exploded. The explosion was rapid as to blow my hand open...and to tear off a part of my nails...Sir Humphrey also received several cuts on his hands and face..." However, the incident hardly deterred either of these two great men from performing more such experiments!

Once, Sir Humphrey Davy, who was by then convinced of young Faraday's potential, 'a fellow-wanderer' in Davy's words, 'into regions yet untrod', invited him to come along as his 'philosophical assistant' on a lecture

tour to Europe. Though the journey proved to be a delightful experience for Faraday, he was somewhat chagrined at the unexpected rudeness with which Lady Davy treated him. Once at Geneva, the three were invited to dinner at the house of the Genevese philosopher Professor de la Rive. Recognising Faraday's equality with the others, his place had been set at the table with the rest of the party. Lady Davy immediately objected to this, insisting that Faraday was her husband's servant and as such must be asked to eat with the other servants. Disgusted with her conduct, the host ordered dinner to be served to Faraday in a separate chamber, as befitted the dignity of "the lonely young philosopher who lived above the petty squables of his fellows." Faraday took humiliation in his stride, silently and with great dignity. He used this experience to write somewhere that "the human mind is a peculiar compound of sublimity and slime."

It is perhaps tragic that the great Sir Humphrey, who was solely responsible for 'discovering' Faraday, launched a bitter tirade against him in his later years. The reason for this was Davy's prized invention, the miner's safety lamp, which the latter had claimed would never explode. The parliamentary committee that was examining the hazards of the British mines asked Faraday to give his opinion on Davy's lamp. Characteristic of him, Faraday gave his honest opinion about the lamp, declaring it to be unsafe. He deeply felt that the life of the miners was far more important than the honour of his teacher. Davy, however resented this, and questioned the competence of Faraday, whom he called a 'young upstart' to comment upon the work of his master. Davy laboured a grudge against Faraday for the rest of his life and got his revenge by casting a negative casting vote against him in the elections of the Royal Society, of which he was the president. And yet, Faraday never bore any grudge against Davy. Years after Davy's death, Faraday was once chatting with Jean Dumas in the library of the

Royal Institution. Suddenly, rising from his chair, he walked up to Davy's portrait on the wall and said in a voice that trembled with emotion, "There, my friend, was a great man."

A few days after he had discovered the basic principles of the electric generator and the dynamo, Michael Faraday was explaining about them to a group of distinguished persons, including Prime Minister Gladstone. Before he could finish, Gladstone interrupted, "But, after all, of what use is it?"

Faraday scratched his head and said simply, "Why, Sir, there is every probability that you will be able to tax it."

Every day after finishing work, Faraday would watch the sunset with his wife, a practice he continued till the end of their days together. He would hold her hand in his and sit quietly in front of the twilit sky, watching the day sail into the darkness of the night. "How old and how beautiful is this figure of resurrection!" he once remarked.

By the year 1857, Faraday had arrived at the forefront of scientific achievement. But his dislike for titles and honours did not change. When the great Professor Tyndall offered him the presidency of the Royal Society, calling him 'the most brilliant scientist of his generation', Faraday refused the honour. "Tyndall," he said, "I must remain plain Michael Faraday to the last." And that is precisely what he did.

A few years before his death, a young man was sent down by the Royal Mint to perform an experiment at Faraday's laboratory. He looked up from his work to observe an old white-haired man, shabbily dressed, watching him whimsically. "I suppose," said the young man, "you've been here for a number of years?"

"Yes," replied the man, "a good many years."

"Sort of a janitor here?" asked the young man again.

"Yes, sort of."

"I hope they pay you well," was the next comment.

To which the old man replied, "I could stand a little better pay."

"And what, my man, is your name?"

"Michael Faraday."

FERMI, ENRICO
Physicist (1901-1954)

This Italian-American physicist was one of the pioneers of the nuclear age. He won the Nobel Prize for physics in 1938, for his work on radio isotopes, and for his discovery of the effectiveness of slow neutrons in producing radioactivity. Fermi's work culminated with the building of the first nuclear reactor on 12 December 1942. Fermi was a brilliant student and had the distinction of completing his doctoral thesis at the age of twenty-one. He then went to study at Gottingen University with Max Born and later in Leiden, the Netherlands, with the physicist Paul Ehrenfest. In 1926, he made his first major contribution to physics with his work on the statistical behaviour of a monoatomic gas, later to be known as 'Fermi gas'. In 1933, he proposed a radically new theory of electrons, which later played a major role in the development of

nuclear physics. His postulation of a neutral particle called 'neutrino' was proved right when it was detected for the first time in 1955. In 1938, Fermi's life took a turn when he went to Stockholm to accept the Nobel Prize. There he decided not to return to Italy, where fascism was directly beginning to affect him as his wife was Jewish. Instead, the Fermis set sail for New York, having accepted a professorship of physics at Columbia University. In 1944-1945, Fermi served as Associate Director of the Los Alamos Laboratory in New Mexico and was awarded the Congressional Medal for Merit in 1946 and the first annual award of the Atomic Energy Commission in 1954. As a great honour, the 100th element, fermium, was named after him.

With his appointment to the Italian Academy in 1929, Fermi found himself wooed by high state officials, although he usually shunned all public functions. In 1930, when the Crown Prince of Italy married, Fermi was also invited to the wedding. He decided to work in his laboratory instead. But to get to it, he had to cross a street on the processional route that had been closed to traffic and was being guarded by a line of soldiers. Fermi, driving his shabby little car and in his usual clothes, was immediately stopped by the soldiers. "I am the chauffeur of His Excellency Fermi," he said, "and I have to fetch him for the wedding. Could you please let me cross the lines?" Whereupon he was promptly led through the lines and spent the rest of the day at work in the laboratory.

A little-known detail about Enrico Fermi was his expertise at repairing cars. Once, while he was repairing a friend's car at a gas station, the owner happened to be watching. After the car had restarted, he walked over to Fermi and offered him a job!

Soon after the Second World War, a Hollywood studio wanted to make a motion picture on the story of the atomic bomb. A hotel suite in south Chicago was booked for a conference to which Enrico Fermi, leader of the team that had devised the first nuclear reactor, and Samuel

Allison, who had played a leading role in the design of bomb, were invited. After the conference, the producer insisted upon dropping them to their homes, which were only a block away, much to the embarrassment of the two men. They were driven home in a large and flashy Cadillac, fitted with white-walled tyres. When Fermi's landlady saw the sight of them alighting from the Cadillac, she remarked, "Isn't it strange how important you little men have suddenly become!"

The announcement in 1939 of the discovery of uranium fission in Germany coincided perfectly with Fermi's migration to the United States. With his associates at Columbia University, he began painstaking research towards the realisation of the first nuclear chain reaction. In 1942, this project was moved to the University of Chicago, where Fermi directed the construction of the world's first atomic reactor, which was a pile of natural uranium embedded in layers of graphite. The venue? The squash court under the stands of the university stadium!

When preparations for the explosion of the first hydrogen bomb were almost complete, Werner Heisenberg suggested to Fermi, "It may be biologically dangerous to explode the bomb."

Fermi agreed, but insisted, "But it is such a beautiful experiment."

FEYNMAN, RICHARD
Physicist (1918-)

Feynman was an American physicist, who shared the 1965 Nobel Prize for physics with Julian Schwinger and Shinichiro Tomonoga, for his development of the relativistic quantum electrodynamics. Feynman's contribution was noteworthy for the great simplification of many calculations, using diagrammatic techniques that are known today as the 'Feynman diagrams'. After receiving his doctorate from Princeton University, Feynman was in-

vited to join the Manhattan Project, to develop the atomic bomb at Los Alamos. After that Feynman taught at Cornell University and later at California Institute of Technology, and came to be recognised as an excellent and inspiring teacher. His later research included work on liquid helium and the prediction of a 'particle' of energy which he called the *vortex exciton*. In 1965, he and Murray Gell-Mann proposed the current theory of 'weak interactions', and in the 1960s, they went on to hypothesise the fundamental particle called the *quark*.

The work on the bomb at the Los Alamos laboratory was being done in utmost secrecy. The young Richard Feynman decided to keep the security officials busy. He instructed his wife to send him letters torn into hundreds of small pieces. The regulations specified that the officials entrusted with checking correspondence should read everything that came or left the centre. They had to painstakingly fit all the fragments of Mrs Feynman's jigsaw puzzle together!

Feynman had another pastime. He took an impish delight in figuring out the combination numbers of the steel safes in which the most important research data were stored. Once he succeeded in opening the main file cupboard at the Los Alamos Centre while the officer-in-charge was absent for a few minutes. He then placed a scrap of paper in the safe, in which he had written a cryptic and maddening, "Guess who?"

The official was utterly bewildered and quite unable to understand how the paper found its way into the innermost sanctum of the Manhattan Project!

After receiving the Nobel Prize, Richard Feynman, while returning home decided to visit his school in New York. On going through the school records he found that his IQ (intelligence quotient) was shown as being fairly low. On reaching home his remark to his wife was that to win the Nobel Prize was of little significance, but the fact that he had won it despite such a low IQ was something great!

FLEMING, SIR ALEXANDER
Bacteriologist (1881-1955)

Fleming of Britain discovered penicillin and shared the Nobel Prize for medicine in 1945 with two other British scientists, Howard Florey and Ernst Chain. Fleming's interest in the problems of disinfection and antiseptics started during the First World War. In 1921, he successfully isolated and described an antibacterial agent, which he called *iysozyme* and which is an enzyme found in tears and mucus secretions. He continued furthering his work and in 1928 discovered penicillin. Owing to the inadequate chemical means at his disposal at that time, it had to be twelve years later that enough penicillin could be obtained and purified for actual use on human beings. Fleming received several awards and retired as professor of bacteriology at St. Mary's Hospital, London. He was knighted in 1948.

Alexander Fleming, the discoverer of penicillin, was a modest, shy and taciturn Scotsman. When his first wife Sarah Marion was seriously ill, one of her friends told her, "You musn't die. What would Alexander do without you?"

"Oh!" she replied, "I'm sure he'll marry again." Then she added with a smile, "But whoever it is, she'll have to do the proposing."

Although Fleming had been working for several years looking for an agent such as penicillin, the actual discovery was itself serendipitous. In 1928, while experimenting with staphylococcus cultures, he noticed that one of the plates that had been left on a window ledge in his laboratory was contaminated by a mould. He also noticed that the bacteria had dissolved and failed to grow in an area around the mould. Fleming identified the mould as a species of penicillium.

When King George and Queen Mary were to visit the laboratories at St. Mary's, Alexander Fleming was asked to display his 'bench technique'. He did, but sus-

pecting that it might not really interest the distinguished guests, he also prepared one of his famous bacterial 'rock gardens' from all the available microbes, producing extraordinary growths in vivid colouring. The story goes that when the Queen saw this overbearing sight, she whispered in complete bewilderment to the King, "What is the use of this?"

Fleming was once forced into an interview in New York by two journalists just as he was about to have breakfast. One of them asked eagerly, in a way that only journalists can, "Sir, what are you thinking about right now? We wish to know what a great scientist thinks while getting ready for breakfast."

Fleming mused awhile on the question and then replied, "I am thinking of something very special," at which point the journalists eagerly drew themselves forward. "I am thinking, whether to have one egg or two."

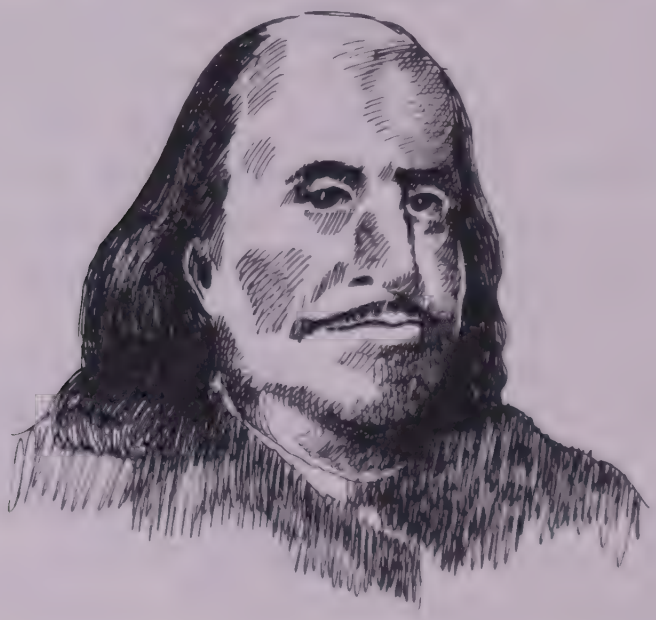
FLEMING, JOHN AMBROSE
Physicist-engineer (1849-1945)

The British physicist and engineer, who invented the first thermionic valve to be used in radios, studied at Cambridge under the tutelage of James Clark Maxwell. John Fleming was an avid experimenter and practical worker and took an active part in the practical application of science. He was an advisor to the Edison, Swan, Ferranti and other lighting companies in England. He made improvements on electric bulbs, meters, generators and methods of distribution. Fleming was also the scientific consultant to Marconi's wireless telegraph company, designing many pieces of early radio apparatus that Marconi used in making the first radio transmission across the Atlantic in 1901. Besides teaching and researching, John Fleming also helped to popularise science through books, articles and papers. His *Memories of a Scientific Life*, combining electrical history with autobiography, is still considered a classic.

A journalist once interviewed Sir Ambrose Fleming on behalf of an Oxford University Press publication. As the journalist began, Fleming interrupted him to ask, "How much do you propose to pay me for this advice?" The interviewer was taken aback, and before he could muster up an answer, Fleming added with a twinkle in his eye, "Why are we scientists always expected to do something for nothing? Now, if I were a lawyer, there would be a proper fee, isn't it?"

FRANKLIN, BENJAMIN
Inventor (1706-1790)

One of the most versatile American personalities ever, Benjamin Franklin was, at different stages in his life, a printer, philosopher, diplomat, scientist and inventor. As a young man, he was deeply influenced by the emerging sciences and the works of Newton in particular, which made him reject his father's Calvinist tradition and turn to 'rational and practical religion', rather than formal doctrines. Denied any education because of abject poverty, Franklin, like Faraday, became a printer apprentice at the *New England Courant*, a Boston newspaper. He went



to England in 1724, where he worked as a master printer and returned to Philadelphia in 1726 to buy his own press. He also became clerk at the Pennsylvania Assembly and postmaster of Philadelphia.

Among his famous scientific experiments, Franklin invented the Pennsylvania fireplace (later called the Franklin stove), an ingeniously energy-efficient heating device. He then turned to electricity and in 1751, began to test whether lightning was a form of electricty. This was confirmed a year later in the famous kite-experiment. He then invented the lightning rod, which soon appeared on buildings all over the world. He also invented bi-focal lenses and the harmonica.

Benjamin Franklin went to the French Royal Court as the American envoy. Just before he was to present his credentials, his head was found to be too big for the official wig used on such occasions. Franklin remained unmoved and went to the court mumbling something about being from the backwoods. The word got around and he found himself being greeted by all present as 'the child of nature from the backwoods'.

While Franklin was in France, a balloon ascent was being attempted from the Champs de Mars on a rainy day in 1783. Franklin was standing among the crowd of people who had come to watch the event. A dispirited sceptic in the crowd turned to him and muttered, "What on earth is the use of the balloon?"

Franklin shot back in his characteristic American way, "Well, what is the use of a new-born baby?"

While working as an apprentice in the *New England Courant*, Franklin, who had had almost no education whatsoever, began reading every word that came into the shop. He then began writing clever pieces for the paper that satirised what he referred to as the 'Boston Establishment'. And he signed the articles as 'Silence Dogood'!

Franklin exemplified the Puritan ethic by philoso-

phising about earning a good living. His *Poor Richard's Almanac* , which became a bestseller in North America, carried simple homelies, such as, '...by hard work, thrift and honesty, a poor man might release himself from the prison of poverty' or '...when you run into debt, you give another power over your liberty'. Although his aphorisms were distorted in time to come, Franklin the scientist personified belief in the capacity of humans to understand themselves and the world in which they live.

Sir Humphrey Davy, in a tribute to Franklin, said, "...By very small means, Franklin established great truths...he rendered his experiments amusing as well as as perspicuous, elegant as well as simple...and he has sought to make science a useful inmate and servant in the common habitations of man, than to preserve (it) merely as an object of admiration in temples and palaces."

FULTON, ROBERT
Inventor (1765-1815)

American inventor, engineer and artist, who is best remembered for having pioneered the first steamship, was brought up in Lancaster, Pennsylvania. As a boy he showed an enormous aptitude for fashioning things, making a rocket, a hand-propelled paddle-wheel boat and even a gun. By the time he was seventeen, he was already supporting himself as an artist by selling his paintings as well as his mechanical drawings. After a chequered career that involved trying to improve the submarine, Fulton formed a business partnership and launched his first steamship in the Seine that travelled at three miles an hour. On 18 August 1807, the steamboat later known as the *Claremont* was launched in New York city, beginning a succesful steam navigation business for Fulton. While testing his steamship for the first time on the Mississippi river, a huge crowd gathered to see the technological

feat. Fulton started his operations for generating steam. After some time, the ship started vibrating and smoke issued from the funnel. The crowd started shouting, "It will never move."

However, after the noisy operations the ship started gliding slowly along the river. The crowd started shouting, "It will never stop." But, stop it did.

Said a narrator of the following incident: "I chanced to be at Albany on business when Fulton arrived there, in his unheard-of craft that everybody felt so much interested in seeing. Being ready to leave and hearing that the craft was going to return to New York, I repaired on board and inquired for Mr Fulton. I was referred to the cabin, and there found a plain, gentlemanly man, wholly alone, and engaged in writing.

"'Mr Fulton, I presume?'

"'Yes, sir.'

"'Can I have a passage down?'

"'You can take your chance with us, Sir.'

"I inquired the amount to be paid, and after a moment's hesitation, a sum, I think $ 6, was named. I laid it on his open hand and with one eye fixed on it, he remained so long motionless, that I supposed there might be a miscount, and said to him, 'Is that right, Sir?'

"The question roused him as if from a kind of reverie, and he looked up to me, a big tear brimming in his eye. In his faltering voice he said, 'Excuse me, Sir, but my memory was busy as I contemplated this, the first pecuniary award I have ever received for all my exertions in adapting steam to navigation. I should gladly commemorate the occasion over a bottle of wine with you, but really I am too poor, even for that just now'."

GALILEO, GALILEI
Astronomer-physicist (1564-1642)

Italian astronomer, physicist and mathematician, who is

credited with the initiation of the scientific revolution in the 17th century, in Italy, made his chief contribution by introducing experimentation and mathematical proof as the crucial test for a scientific theory rather than teleological explanation. The essence of his work is contained in his *Discourses and Mathematical Demonstrations Relating to Two New Sciences*, published in 1638, and in which Galileo systematically disproved all the assumptions made in the prevailing Aristotlean physics. His legendary experiment in which he is supposed to have thrown two objects of unequal weight from the tower of Pisa was one such effort.

As a young medical student, Galileo was kneeling in the cathedral. An oil-lamp was swinging in the air above him. The tick-tack of the swinging chain drew the young student's attention to it. Suddenly he jumped to his feet and to the astonishment of the others in the church, ran out, gesticulating wildly. What Galileo had perceived was that the pendulum of the rattling chain was taking exactly the same time for every oscillation, although the length of these oscillations was constantly reducing. When he got home, Galileo worked out in detail the intricacies of this kind of motion. Today this finds application in the counting of the human pulse, solar eclipses and the movement of stars.

Although Galileo was not interested in astronomy in his early years, he became fascinated after reading copies of a Copernican book in 1597, that had been published by Kepler. Galileo wrote to Kepler that he endorsed Copernicus' theory about the rotation of the earth as it fitted in perfectly with his explanations of tides. The same year, he manufactured the proportional compass. In 1607, he invented a power telescope, three times as powerful as the first one that had been manufactured in Holland: this invention was to guarantee Galileo a lifetime professorship and a large salary. He became involved in a controversy in 1612, when he published a book, openly

refuting Aristotle and endorsing Copernican ideas. His book was attacked from the pulpit and an inquisition was called for, that forced Galileo to recant his point-of-view.

Galileo was summoned to appear before the Inquisition for having openly published a book that supported the view that the sun, and not the earth is at the centre of the universe. The trial lasted six months and on 22 June 1633, he was compelled to retract his belief in the movement of the earth. "Before the holy saint gospels which I touch with my hands, I confess that my error has been one of vain ambition and pure arrogance...I now declare and swear that the earth does not move around the sun..." And as he was led away from the tribunal, trembling and exhausted, Galileo remarked under his breath, three words that seem to epitomise the founding spirit of science—"*Eppur si muove*" (but the earth does move).

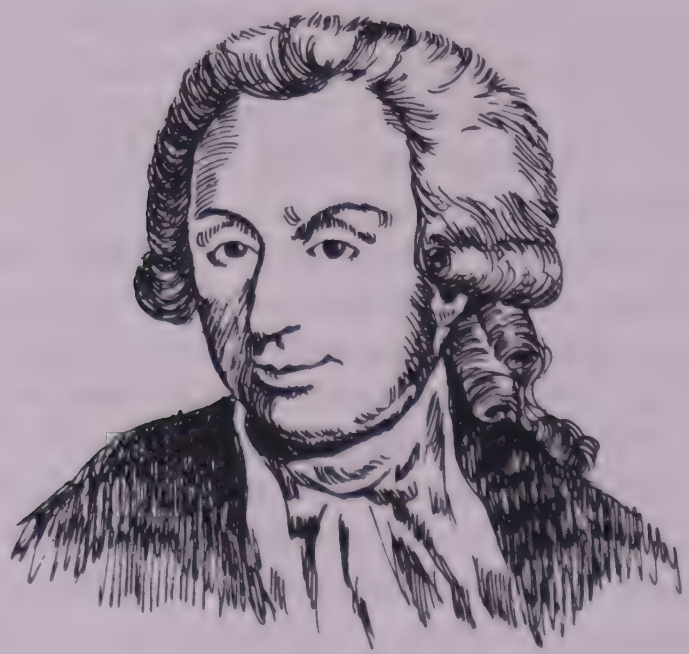
As a non-conformist in more ways than one, Galileo kept getting into situations that made life occasionally difficult. For example, he refused to wear the academic robes worn by his colleagues, explaining that they unnecessarily restricted his movements. However, for his refusal to wear the right attire, Galileo was forced to pay several fines that were deducted from his meagre salary. At length his enemies prevailed and Galileo was dismissed from the faculty at Pisa.

Although Galileo had received orders to refrain from writing another book, he did write one while in prison at Arcetri. It was called *The Laws of Motion*, and was a summary of all the basic principles of mechanics. However, he had to have the manuscript smuggled out to Holland for its publication. But he could never see the book as he had grown old in prison. The story goes that a copy was secretly brought to him on his death-bed. Too weak to read, he held it close to himself and said, "I esteem this the most of all my works. It is the outcome of my extreme agony."

GALVANI, LUIGI
Physiologist (1737-1798)

The Italian physiologist, who did pioneering research in the field of animal electricity, studied medicine and taught anatomy at the University of Bologna. In 1791, after painstaking research on the effects of atmospheric electricity on the muscular response of frogs, he stated that animal tissues generate electricity. However, this theory was eventually proved wrong.

It is not very often that two scientists leave behind a legacy of dispute that is then continued for years by their mutual supporters. Galvani and Volta did precisely that; the latter, also an Italian, challenged Galvani's theory of animal electricity by saying that the results were due to the action of ordinary physical electricity generated outside the animal. Anyway, the dipute lasted for several years and on one occasion at a public demonstration supporters of both Galvani and Volta almost came to blows over the issue. Galvani was finally proved wrong, but an electric device for detecting electric current was named in his honour.



GAY-LUSSAC, JOSEPH LOUIS
Chemist (1778-1850)

This French chemist and physicist is best known for his pioneering work on gas laws. He taught physics at Sorbonne and later succeeded Berthelot as professor of chemistry at the Ecole Polytechnique. In 1802, Gay-Lussac reformulated Charles' law of thermal expansion of gases after extensive experimentation. In 1806, he announced the law that now bears his name, which states that gases combine chemically in simple proportions by volume. This law was contested by Dalton but supported by Avogadro, who used Gay-Lussac's law in developing his hypothesis. Gay-Lussac also obtained sodium and potassium in 1808 and in 1815 was the first to obtain anhydrous prussic acid (an acid without oxygen). He also developed new methods of volumetric analysis.

Gay-Lussac was interested in finding out the chemical composition of the atmosphere at high altitudes. His physicist friend Jean Baptiste Biot was at the time studying the behaviour of a magnetic needle, not necessarily, at sea-level. Thus the two friends decided to do the only thing that was possible in those days—a daring balloon flight that would take them to more than 7,000 metres. At an elevation of about 7,016 metres, the balloon stopped ascending and so Gay-Lussac started throwing all kinds of things off from the balloon, including shoes, his coat and finally the chair he was sitting on. The story goes that as the white wooden chair came flying down to land in some bushes, a shepherdess who was minding her business was completely astonished at the sight she beheld. The peasants who heard her story reported that the shepherdess was at a loss to explain why, if the chair had come from heaven, the workmanship on it could be so crude.

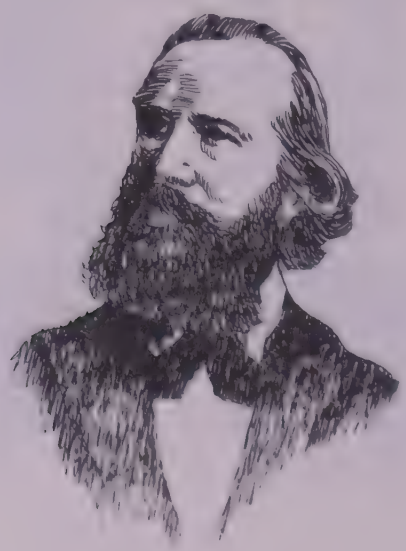
GIRAUD, MARIUS
Ornithologist (dates unknown)

This French bird-watcher is credited with being one of the first to categorise and study bird habits and behaviour in detail. He was also renowned for his techniques of studying birds in their natural habitat, and would often go to extreme lengths to achieve this.

Marius Giraud used to spend several hours in his garden every day practising bird calls. After several years of practice, he thought he had finally mastered them and ventured out into a nearby wood to see if he was proficient enough to attract any birds. He was obviously extremely convincing, for he was promptly shot at by a bird-hunter!

HAECKEL, ERNST HEINRICH
Biologist (1834-1919)

This German biologist became famous for important discoveries in embryology and zoology and for his ardent support of Darwin's Theory of Evolution. Haeckel began his studies in botany at the University of Berlin and later studied medicine and earned his M.D. at Berlin. However, he soon abandoned medical practice, and joined a



scientific expedition to Messina to study radiolaria, on the merit of which he was appointed professor of zoology in the University of Jena. It was here that Haeckel did his work on embryology. After Darwin published his Theory of Evolution, Haeckel quickly became an exponent of the theory in the continent. He advocated Darwin's theory with forceful and dogmatic assertion, and often got involved in controversies over the issue as a result of his arguments.

Embittered by the incessant nagging of an utterly selfish daughter and an invalid wife, Haeckel found solace in a clandestine relationship with a woman several years younger than him. But torn between his disloyalty towards his own wife and his infatuation for Franziska, the younger woman, Haeckel decided to set sail on a trip to the Indian Ocean. He wrote to her while he was on board, "Franziska dearest, best beloved wife of my heart, I depart for the tropical seas to escape from you and from myself—two rare and extraordinary souls made for each other who, separated, must wander lonely through life..." Haeckel travelled far, to Singapore, Java and Sumatra, but his sorrow stayed with him wherever he went. Finally he wrote to Franziska, "Man escapes himself nowhere." Shortly after his return, the young Franziska died of heart failure.

Haeckel had a peculiar way of exercising his chest, "to make it breathe deeply," he would explain. He would stand at the open window of his bedroom and pound heavily on it with his fists, arousing quite a few giggles from the passersby as a result. On some days, he would pound on his chest with both fists all the way from home to college, leaving behind a trail of chuckling students!

HAHN, OTTO
Physical chemist (1879-1968)

The German chemist was given the 1944 Nobel Prize in

chemistry for his work on nuclear fission. After his doctorate in organic chemistry from Marburg University, he went to London in 1904 to participate in the search for new radioactive elements, and worked with Sir William Ramsay. During his stay there, he discovered radiothorium. After a year, he accompanied Ernest Rutherford to McGill University in Montreal, and while there he discovered radioactinium. Returning to Berlin in 1906, he discovered mesothorium. All his future work involved a partnership with the Austrian physicist Lise Meitner, with whom Otto Hahn worked for thirty years. In 1932, in the wake of Fermi's series of experiments on neutron capture, Hahn turned to the study of neutrons and of identifying the results of the neutron bombardment experiments of Fermi. This led Hahn, along with his associates Lise Meitner and Fritz Strassman, to the secret of the 'chain reaction', the key behind the atomic bomb.

The story of the the birth of the first atomic bomb is a curious one. During the 1930s it was well known to physicists and chemists that Enrico Fermi was doing a series of very new experiments on uranium in which he was hoping to build up the uranium nucleus by a process known as 'neutron capture', into heavier forms, known as trans-uranium nuclei. Hahn then began studying Fermi's results which he found 'very confusing'. He found to his intense surprise that one of the products of the experiment was an unexpected element called barium, which curiously enough has an atomic number of 56 and is close to being half of the atomic number of uranium. However, Hahn and his associate Strassman chose to ignore the implications of this and when they published their paper on 6 January 1939, stuck to just the bare facts, without venturing into anything else. At that time, Hahn's other associate Lise Meitner was in Sweden. She and her nephew, the renowned Otto Frisch, read the paper in Sweden and took courage to say that from the curious appearance of barium, it seemed that the nucleus had

been split! This started a series of experiments all over again which confirmed the splitting of the nucleus and that the process produced more electrons than were needed to begin the initial fission. This was the start of what is called the 'chain reaction', which is, of course, the basis for the atomic bomb. During the Second World War, Hahn worked against the possible attainment of the atomic bomb by the Nazis.

When he went to London in 1904 to work with Sir Ramsay, the young Otto Hahn also spent time trying to learn dancing. He described, in his own words, his early attempts to learn the art: "I found a very young lady who was prepared to be my partner while I made my first attempts at the new steps. As we were dancing on beautiful soft carpets and I wanted to make at least a little conversation, I said, 'You, here in England, you dance on the carpet. We, in our country prefer to dance on the naked bottom'. The young lady stared at me in utter bewilderment, then walked off, turning her back to me, and never looked at me again the whole evening. When I repeated the episode to Ramsay's son, he laughed and explained to me where my English had gone fatally wrong."

News of Hahn's wedding spread rapidly. Said the chauffeur of a friend, "Dear, dear...and Professor Hahn was always such a cheerful gentleman!"

Hahn was once being interviewed. In response to a question, he replied, "We always worked without protection. We handled our preparations with our bare hands and stirred them around with our fingers. And under the table on which Lise Meitner and I worked, we kept a crate that always contained between 150 and 250 kilogrammes of uranium salts. Nowadays chemists and physicists would have a fit if anyone suggested they should expose themselves day in and day out. But it never did us any harm. I did sometimes have sore fingers, but that passed off. Only the nail of my left forefinger refuses to

grow again. No, I can't report ever having suffered any serious trouble. I am always rather suspicious of people who make a great fuss."

HALDANE, JOHN BURDON SANDERSEN
Biologist (1892-1964)

Haldane, the British geneticist, made important contributions to the mathematical analysis of genetics and evolution. He formulated his theory in the 1920s, at the same time as two other British geneticists, Fisher and Wright. Haldane's investigation included mathematical analyses of mutation rates, intensities of selection, and rates of evolutionary change. Haldane also did some significant research on colour blindness and haemophilia. He did pioneering work in biochemical genetics of primrose and did experimental work in human physiology. Haldane taught at Cambridge and at University College in London. Two of Haldane's books, *Enzymes* (1930) and *The Causes of Evolution* (1932) are acclaimed as scientific classics.

As a two-year old, Haldane stood before a mirror, making curious faces. He was trying to copy various dogs, and experimenting how best to look like the dogs he had seen near his house. This quality of experimenting with himself was to remain throughout his life. He used to conduct horrifying experiments upon his own body to test its behaviour under different conditions.

J.B.S. was popular among his troops during the First World War and regarded as something of a hero. He apparently used to sneak into enemy lines at night and return with invaluable information. Once while snooping and eavesdropping, he heard a nasty remark being made about Britain. He dropped a bomb in anger, and barely managed to escape under heavy fire!

In addition to his great trust and confidence in scientific research and the inherent value of science, Haldane

was also a committed communist. He was a member of the British Communist Party and spoke critically of the ruling party on political platforms. Faced with disillusionment about the future of England, he decided, in 1957, to emigrate to India—a country which he had always been very fond of. Haldane became a naturalised Indian citizen in 1961 and never returned to England again.

In the beginning of his stay in India, Haldane shared his flat with his male secretary. When he learnt that the latter's young fiancee was coming to stay with them in the same flat, the elderly biologist wrote a letter of welcome to her. However, he cautioned her, "It is only fair to warn you that you should probably avoid being on the roof with me at night. This is not for the reason which you might think, for I am sixty-five years old and love my wife; but because I am liable to start talking about stars and you may find this very boring!"

At the age of 71, Haldane died of cancer at Bhubaneswar. Even during his painful illness, Haldane remained his normal cheerful self. He even wrote a merry poem, *Cancer's a Funny Thing*, in his last days, and considered by many who have read it as one of the best poems on the subject.

HALL, CHARLES M. and HEROULT, PANT-LOTUS-TOUSAINT

(1863-1914) and (1863-1914)

Hall and Heroult simultaneously developed the electrochemical method of isolating aluminium, the most abundant element in nature.

Hall, a student at Oberlin College, inspired by the accounts which Prof.F.F. Jewelt had given of his studies, decided that his suprême aim in life would be to devise a cheap method for making aluminium. In an improvised laboratory in the woodshed and with home-made

batteries, he struggled for some years with his experiments. On 23 February 1886, this boy of twenty-one years rushed into his professor's office and held out to the latter a handful of aluminium buttons. Since these buttons led to a highly successful electrolytic process for manufacturing aluminium, the Aluminium Company of America treasures these buttons to this day and refers to them affectionately as the 'crown jewels'. A beautiful statue of the youthful Charles M. Hall, cast in aluminium, can be seen at Oberlin College.

At the same time, French metallurgist Heroult developed an identical method of isolating aluminium. The simultaneous discovery led to legal battles in law courts for the priority of patent rights. This however did not prevent Heroult from travelling to the USA to felicitate Hall at the award-winning ceremony for the Perkin Medal. He established with his action that petty jealousies do not affect great scientists.

HALSTEAD, WILLIAM STEWART
Surgeon (1852-1922)

This American surgeon made important contributions to the development of surgical techniques and the teaching of surgery. Halstead studied at Yale and received his M.D. from the College of Physicians and Surgeons in New York. He served as professor of surgery at the John Hopkins hospital, where he developed improved methods for operations on hernia and breast cancer. Halstead always stressed on the relationship between surgery and physiology, and emphasised the need for careful handling of tissues and avoidance of excessive blood loss. He passed these ideas to future surgeons trained in the hospital's residency programme—a programme Halstead introduced for the first time in the USA on the basis of his experience in Germany.

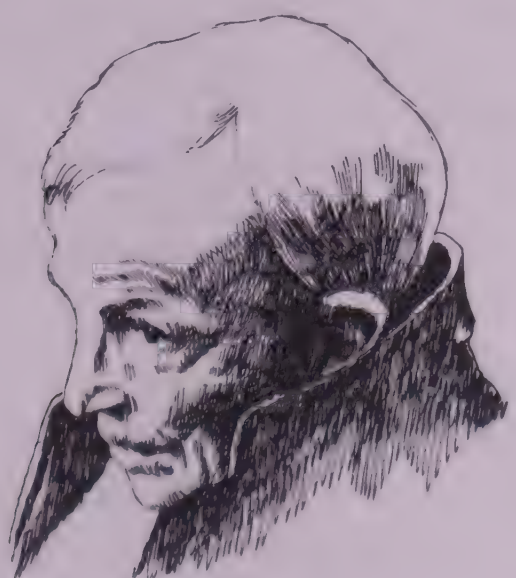
As has happened so very often in the development

of science and technology, the use of rubber gloves in surgery was equally serendipitous. One of the theatre nurses of Dr Halstead once developed a nasty rash on her hands from contact with antiseptics. Halstead thought about a possible solution and came up with the idea of using gloves made out of rubber, instead of the cotton ones which everyone was using then. He started using them himself and it soon caught on...

In 1880, Halstead and his co-workers discovered the amazing anaesthetic properties of cocaine which served as an excellent nerve block. It worked very well, but there was soon a problem at hand—Halstead became addicted to cocaine and almost lost his medical career. However, he was hospitalised and recovered soon enough to go on to become the leading surgeon of his time.

HARDY, GODFREY HAROLD
Mathematician (1877-1947)

Hardy, the British mathematician, is credited with two important contributions to the world of mathematics: *firstly*, for his important discoveries in every branch of mathematical analysis, and *secondly*, for his patronage of the



Indian mathematical genius Srinivasa Ramanujan. Hardy was a professor of pure mathematics at Cambridge from 1931 to 1942. He was a prolific writer and published over eleven books, of which his *Collected Mathematical Papers* comprised seven volumes. Hardy was also an avid fan of the game of cricket and wrote a popular book, *Apology*, in 1940.

Hardy, the great mathematician, was also a staunch agnostic. Once, while watching a cricket match at Lord's, he saw an English batsman at the crease being troubled by a bright reflection from the stands. When he complained to the umpires, the game halted momentarily as the linesmen, umpires and the match organisers ran around trying to locate the source of the light. Finally it was discovered to be coming from a large cross hanging on the broad chest of a Catholic clergyman. Of course, the umpires had to request this man of God to remove the cross. Hardy was so delighted when he saw the cross being taken off, that at lunch he immediately began writing cards to his clerical friends to inform them of the plight of their reverend brother!

Hardy was a pure mathematician who had absolutely no interest in any practical application whatsoever. In fact, he kept emphatically insisting that in no way did he wish to be linked to anything practical. It was therefore rather ironic that one of his 1908 papers was directly useful in the study of RH blood groups. Since the same principle of population genetics was discovered independently by the German physician Wilhelm Weinberg, it is known as the Hardy-Weinberg principle.

HAWKING, STEPHEN

Theoretical physicist and mathematician (1942-)

Hawking was born on 8 January 1942, the date which happens to be the three hundredth death anniversary of Galileo Galilei. When this was pointed out to him at the

peak of his career, his only reply was that thousands of children all over the world must have been born on the same date.

At the age of twenty-one he was struck by an incurable disease of motor neurons which affects the nerves of the spinal cord and parts of the brain that facilitate voluntary motor functions. While the body gradually wastes away, thought and memory processes remain intact. Such a person has to depend upon exosomatic appliances for physical functions like movement and speech.

Doctors had given him only two to three years of life but Dr Stephen Hawking, Lucasian professor of mathematics at Cambridge, has crossed his 50 years and continues to live till today.

A friend of authors, Dr A.B. Pandit had the good fortune of meeting Stephen Hawking when carrying out research in chemical engineering at Cambridge. He has to say this about Stephen Hawking: "During my stay at Cambridge for nearly eight years for my own research work, for the first time I saw Stephen Hawking in his wheel-chair, zooming around in Cambridge. I did not know who he was but his face reminded me of a photograph I had seen during my college days in *Science Today*. I then remembered the article and realised who he was and how he had widened the horizons of astrophysics with a discovery in black hole thermodynamics. A few weeks later I had the opportunity to have dinner with him at the university when I could not resist the temptation of entering into a conversation with him. Though his speech was barely discernible at that time, it was indeed very exciting to talk to him about things in general, related to Cambridge and India.

"One thing which struck me most at that meeting was his intense desire to communicate and the conviction with which he spoke. My first apprehension on my inability to communicate with him was soon forgotten and I did not realise that I was talking to a person with such a severe

handicap. I think he also realised that and the subject of his disability never crept up in our conversation. We talked for about fifteen to twenty minutes. He was a real model for disabled people. He said in one of his speeches before an occupational science conference: 'It is very important that disabled children should be helped to blend with others of the same age. It determines their self-image. How can one feel a member of the human race if one is set apart from an early age? It is a form of apartheid'.

"When asked what was the greatest regret he had because of his severe physical disablility, he replied 'I miss playing with my children'.

"I could not agree more with his views on the oriental approach to astrophysics, as it dealt mainly with the elaborate calculating procedure rather than developing a quantitative understanding of the evolution of the universe. Next time I had another opportunity to dine with him and this was at the Gonville & Cains College. During the fellows' dinner where I was a guest, the conversation ranged on varied subjects and I could get a little more insight into the man's mind. By this time, he had acquired a voice synthesiser and frequently complained about its accent, which is a well-known joke today. Though, in my opinion, this passionless voice was most suited for his work on astrophysics as he was very impartial about proposing and repudiating his own theories, it was an object lesson for a person like me who was just starting his research career in chemical engineering. Single-mindedness towards work and dispassionate approach towards one's work were the two key points which I learned from Prof. Hawking."

HEISENBERG, WERNER KARL
Physicist (1901-1976)

This German physicist won the 1932 Nobel Prize for his creation of quantum mechanics. Heisenberg was a

protege of mathematician David Hilbert and physicist Max Born under whom he studied at Gottingen after taking his doctorate from the University of Munich. Subsequent to Gottingen, he spent the next year in Copenhagen, working with Neils Bohr. Later he served as professor of theoretical physics at the University of Berlin and as Director of the Kaiser Wilhelm Institute of Physics. Heisenberg's contribution came at an appropriate time when the world of physics was a buzz of confusion and anticipation, following Bohr's new atomic theory. Heisenberg turned to the mathematics of 'matrices', replacing the earlier mechanical model of physical reality by a complex mathematical system. In 1927, he stated his famous 'uncertainty principle', which holds that at the atomic level, events cannot be predicted exactly; only the statistical probability of such events can be determined. Together with the other emerging quantum mechanical theories of the time, Heisenberg's uncertainty principle completely transformed the familiar world of 19th century physics.

Heisenberg and his other physicist-friends were in the habit of taking a modest mid-day meal at a pub opposite their lodgings. "One day," recalled Heisenberg many years later, "the landlady, to my surprise, called me into her room and informed me that we physicists could no longer eat at her place since the eternal talk of physics at our table was unbearable for the other guests!"

Heisenberg once compared his research to the experience of mountain climbing. "The climber," he said, "immersed in fog has only a vague idea of the location and condition of the peak he intends to ascend. Determined not to give in to difficulties, he keeps going, one step at a time, but he does not really know whether he is moving towards the peak or not. Then all of a sudden, the fog clears away for a moment. The climber recognises the goal of his striving as well as the surrounding situation. He sees a pattern and at that very moment, the

whole picture changes completely." In the same context he once wrote to a colleague, "There was a moment when I received sudden inspiration and saw that energy was constant with respect to time. It was fairly late at night that I worked this out laboriously, and it was correct. Then I climbed a rock and saw the sunrise and was happy."

When a telegram arrived from Stockholm on November 9, after the semester had started at Leipzig, Heisenberg immediately rushed to the phone and called his mother in Munich, "Mama, I congratulate you on your son...I've just won the Nobel Prize!"

Heisenberg, however was far from enjoying his fame as a Nobel laureate. He wrote, "With this prize, I have a bad conscience as far as Schroedinger, Dirac and Bohr are concerned. Schroedinger and Dirac, both deserved a full prize just as much as me, and I would have gladly shared the prize with Bohr..."

Once Niels Bohr received a cryptic letter from Heisenberg which ran: "I am sometimes somewhat afraid about how a marriage can be combined with work in physics, but your example, more than anything else, has strengthened my courage there..."

At a war-time meeting of German nuclear scientists in England, a suspicious Diebnev asked before the proceedings were to begin, "I wonder whether there are built-in microphones here?"

Heisenberg laughed and jokingly replied, "Oh no, they aren't that sly. I don't think they know such Gestapo methods. In that respect they are a bit old-fashioned."

At the end of 1970, Heisenberg, then sixty-nine, retired from his position as Director of the Max Planck Institute. In his farewell speech, he philosophised, "...The troubled times have passed, and we could meditate in peace on the great questions that Plato raised, questions that had perhaps found an answer in the physics of elementary particles."

HERSCHEL, CAROLINE LUCRETIA
Astronomer (1750-1818)

This British woman astronomer to make a mark was born in Hanover. She is credited with the discovery of eight comets. She was awarded the gold medal of the Royal Astronomical Society for her catalogue of clusters and nebulae observed by her brother and herself.

The singular motivating force in Caroline Herschel's life was her absolute devotion to her brother. She followed him to England in 1772. There she began a successful career as a soprano soloist in performances conducted by her brother. When William Herschel turned to astronomy, she immediately became his assistant, often working until daybreak and carrying out extensive calculations. Tragically, she could never come into her own: William's marriage in 1788 was a shattering blow to her morale and she could never recover from it. Caroline later destroyed all her journals from 1788 to 1798 which were filled with valuable astronomical data. When William died in 1822, she returned to Hanover.

HERSCHEL, SIR JOHN FREDRICK WILLIAM
Astronomer (1738-1822)

Herschel was the British astronomer whose efforts in astronomy founded the science of galactic structure. He discovered the planet Uranus, over 2,500 star clusters and nebulae, over 800 double stars, as well as the infrared radiation. William Herschel also showed that most apparent double stars are actually physical systems of stars held together by gravity. He made a mark in building large telescopes; the one he built in 1783, with a 40-foot reflector, remained the largest telescope used until 1969. William Herschel was knighted in 1816.

Sir William Herschel built the first of his giant telescopes in the year 1769. Before the lenses were fixed and the telescope erected, various distinguished guests were invited to stroll through the telescope tube, which measured more than 30 feet! The King was there too, one day, along with the Archbishop of Canterbury, who was finding the tube a trifle slippery to walk in. Quipped the King mischievously, "Come my Lord Archbishop, I will show you the way to heaven!"

There was much speculation afoot on the appearance of stars. A dinner was held at which Henry Cavendish was seated next to Herschel. Cavendish started the conversation by inquiring politely, "Is it true that the stars are round?"

"Round as a button," replied Herschel, with a deadpan face.

An eloquent silence followed. At the end of the dinner, Cavendish timidly ventured again, "Round as a button?"

"Round as a button," replied Herschel, and there ended the conversation!

HUMBOLDT, BARON ALEXANDER VON
Scientist (1769-1859)

Humboldt was a German scientist, explorer and diplo-

mat, especially renowned for his explorations in the Americas and Asia. Humboldt was one of the most versatile naturalists of all time and his diverse contributions to science include works in geography, botany, climatology and geophysics. He was also responsible for important improvements in mining methods. Humboldt was also renowned for possessing a phenomenal encyclopaedic brain and could talk on virtually any subject. He was also a prolific scientific writer and had numerous publications to his credit.

One of the greatest naturalists and travellers of all time, Alexander von Humboldt remained humble and modest till the very end of his life. In his later years, he would often remark to his friends, "You should have known my brother William. He was by far the clevèrer of us two." In his greatness, he always regarded his elder brother as a real teacher and himself as a mere pupil.

An account of Humboldt's travels alone would fill volumes. In 1799, he set sail for Venezuela from Spain with the French botanist Aime Bopland. After exploring the coastal area, they travelled inland into one of the least known and most hazardous regions of the Americas, navigating the Orinco and the Rio Negro on native boats. From this trip, Humboldt came back with a treasury of knowledge—thousands of unknown tropical plants, zoological and geological collections, and astronomical and geomagnetic data. His next trip was in December 1800 to Cuba, where he was appalled by the conditions of slave labour, and of which he wrote critically. From there he sailed to Colombia and then to Ecuador, where he nearly succeeded in scaling Mt. Chimborazo, climbing to a height of 18,893 feet, without much equipment. Then he surveyed the headwaters of the Amazon and trekked along ancient Inca trails in Peru. After that, Humboldt studied the current in the Pacific Ocean, which is now named after him. In 1803, he went to Mexico, where he spent a year studying the country's economic resources

and its pre-Columbian antiquities. His next trip was to the United States, where he was greatly attracted by the ideals and institutions of democracy and freedom. He visited Thomas Jefferson in Washington and also James Madison, Albert Gallatin, and the painters Gilbert Stuart and Charles Wilson Peale. Humboldt campaigned fiercely for ending slavery and won many friends and admirers in the USA. He finally settled in Paris in 1808, and spent the next four years writing an exhaustive account of his travels and of the scientific discoveries in the Americas. The publication ran into some 12,000 pages and was acclaimed by scholars and scientists as a masterpiece. However, it was too scholarly for the general public and hardly a copy was sold. Humboldt had sunk all his money into the publication which led to his financial ruin!

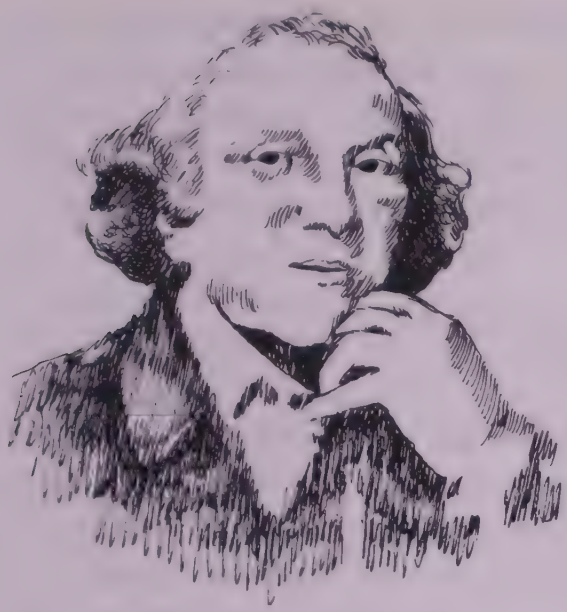
Shortly before he died at the ripe age of ninety, Humboldt was visited by Bernard Taylor, the American poet, who had travelled all the way to Berlin to meet him. When ushered into Humboldt's study, he found the white-haired scientist at a table that was covered with sheets of paper. Taylor found that there were proofs of a new volume of *Cosmos*, awaiting publication. "This is what I have been doing since you were last here," said Humboldt to an amazed Taylor. "Several of the volumes have already been published. This one is just about to go to press."

"Do you find yourself capable of such exacting labour?" asked Taylor.

"I sleep very little," said the old scientist. "Work is my life. The day before yesterday, I worked for sixteen hours without a break, correcting these sheets."

HUNTER, JOHN
Surgeon (1728-1793)

This British surgeon pioneered scientific surgery at a time when leading surgeons in London taught by apprentice-



ship and limited their lectures and writings to case histories, descriptive anatomy and theoretical discussions of surgical procedures. Hunter maintained that surgery should be based on a thorough knowledge of physiology. He is best remembered for his operation of pathological distension of the artery behind the knee joint. It is acclaimed as an outstanding surgical innovation that Hunter had derived from his experimental studies on animals. Hunter also collected many specimens, which are now lodged in the Hunterian Museum in London. His masterpiece, *A treatise on Blood, Inflammation, and Gunshot Wounds*, appeared after Hunter's death in 1794.

Hunter was a popular professor and his lectures on anatomy were usually well attended. One day, however, when he arrived for his morning class, he found only one solitary student sitting on the front bench. The student heard Hunter mutter, "I cannot waste my time on only one student," after which he dashed outside. Hunter returned again, this time clasping a human skeleton to his chest, that he lovingly placed in a sitting position, adjacent to the startled lone student. Humboldt paused, took a breath and began, "Gentlemen, we were discussing...!"

John Hunter also prophesied his death, albeit in a more scientific way. Hunter had a violent temper and he was sure that his death would be caused by 'angina pectoris'. Sure enough, that is exactly how Hunter died. He had a heart attack after a fit of rage!

HUXLEY, SIR JULIAN
Biologist (1887-1975)

Huxley was a British biologist and humanist, who made important discoveries in the field of biology and played a leading part in the introduction of experimental methods and concepts into biological research and teaching. The 'new sytematics' owes its inception to Julian Huxley, who showed that the study of the differences between species must not be restricted to comparisons of museum materials, but must involve an integration with studies in ecology, genetics, population analysis, statistics, ethology and other areas. Huxley was one of the first biologists to go out into the field, instead of confining himself to the four walls of the laboratory viewing specimens under a microscope.

In 1942, Julian Huxley wrote, what is a definite classic, *Evolution: The Modern Synthesis*, covering all aspects of evolution. He taught in Britain and the United States, was the first Director-General of UNESCO in 1946-48, was elected a fellow of the Royal Society in 1938, was awarded its Darwin Medal in 1958, and was knighted in 1958. He wrote a great many articles in scientific journals and in addition to his definitive work on evolution, wrote several other books including *Evolution in Action* (1953) and *Religion without Revelation* (1957).

Julian Huxley was born into a family whose history reads like a *Who's Who* book. His father Leonard Huxley was a brilliant biographer and historian, his grandfather Sir Thomas Huxley a noted scientist, his brother Aldous Huxley a great thinker and writer and his half-brother

Andrew Fielding Huxley a Nobel laureate in physiology.

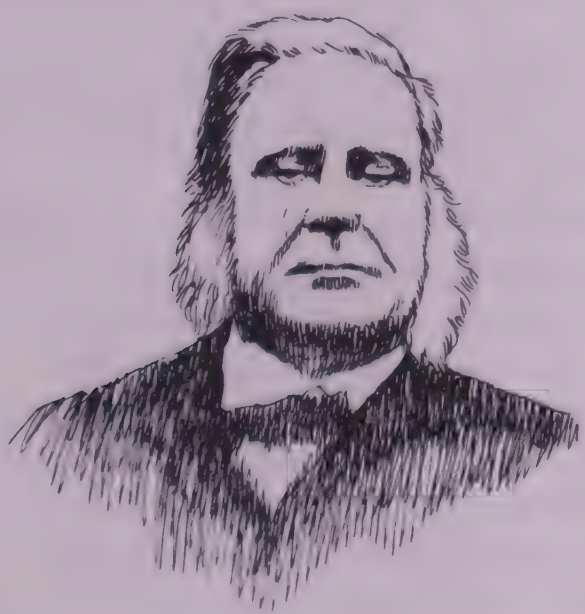
Julian Huxley, like his illustrious grandfather Thomas Huxley, also tried his hand at poetry. "I was letting my brain get lop-sided, so I wrote a volume of poems as a safety valve. I found relief from my laboratory by writing about the beauties of brooks and sunsets," he said.

All convention was flouted in the way Sir Julian Huxley appointed his staff. During the mid-thirties he had to interview a candidate for the headship of a department in the London zoo. A few days later, the candidate sought a second meeting with Huxley to tell him, "When you get the reports from back home, you'll find that I'm a chap who's always been in opposition and always had rows with the government."

"Suits me fine," replied Huxley. "You're hired."

HUXLEY, SIR THOMAS HENRY
Biologist (1825-1895)

As a British biologist, Sir Thomas is seen as one of the founding fathers of 19th century biology, with his detailed investigations in comparative anatomy, palaeontology and evolution. Huxley was also one of the first to accept



Charles Darwin's Theory of Evolution and did much to support and publicise Darwin's work. After passing his examinations from the Royal College of Surgeons, Huxley sailed on the *H.M.S. Rattlesnake* as assistant surgeon on a voyage to explore channels north of Australia.

At a halt in Australia, he fell in love with a 'lady love exceedingly fair with soft blue eyes and yellow hair'. But they decided not to marry until Huxley had made a reputation for himself as a scientist. His friends advised him that the only way of making a quick reputation was to do a 'little trumpeting'. And so the shy and sensitive Tom, who had a pathological fear of talking to crowds, found himself at the British Association, giving a lecture on 'Oceanic Hydrozoa' to a group of scholars on the subject, who had a habit of 'waving and wagging one coat-tail when they applauded'. This act of feigned assurance that concealed a jittery heart did not fail to make a small impact and a small notice did appear in the *Literary Gazette*. This was the beginning of Tom's journey to fame as the most promising scientist in Europe, and all this for the love of a girl whom he married seven years later.

When Henrietta arrived in London for the wedding, she was in extremely poor health as a result of an earlier wrong treatment. The first thing he did was to take her to an eminent physician who gave her six months to live. Huxley, a doctor himself, told him, "Six months or not, she is going to be my wife."

Huxley met Charles Darwin in 1851 and the two maintained a close relationship thereafter. This association continued despite the fact that though Huxley originally believed that species are immutable, he supported Darwin whole-heartedly. Huxley was a member of the elite council of the Royal Society and served on the London School Board where he exerted a lasting influence on educational techniques. He was a brilliant writer and wrote on biology as a specialist and as a populariser,

with a sincerity that did much for the propagation of science throughout the world. He also wrote on philosophy and theology in which he attacked some orthodox dogmas and beliefs.

Thomas Huxley's first scientific paper was written at the age of twenty, on a previously unstudied layer of the hair follicle. Even today, this is still known as Huxley's layer! He was elected to the Royal Society at the age of twenty-five and to its council at the age of twenty-six. And it was not until two years later that he applied for his first academic post!

Huxley's lectures were noted for his wit, brilliance and biting sarcasm. Once during a class, he picked up the notebook of a student who had been trying to draw a sheep's liver with miserable results. Huxley inspected the drawing for a few minutes, and handed the notebook back. "It reminds me," he said acidly, "of the Cologne cathedral in a fog."

In another class, at the conclusion of a his lecture, he asked his students if he had been understood. One bold voice spoke out, "All, Sir, but one part during which you stood between me and the blackboard."

"I did my best to make myself clear," Huxley retorted, "but it seems I couldn't render myself transparent."

A controversialist by nature, Huxley engaged in numerous debates with the clergy. Once at a convention of the British Association in 1860, the Bishop of Oxford asked Thomas Huxley with some measure of sarcasm, "I beg to know from whom you claim your descent—from a monkey, your grandmother or your grandfather?"

The audience was aghast and all heads turned to Huxley, who replied without even a moment's hesitation, "There is no need for me to be ashamed of having an ape for my grandfather. If I might possibly feel ashamed of calling someone an ape for my ancestor, he would be a man like the Bishop of Oxford!"

Huxley had become notorious as a spokesman for Darwin and used to participate vociferously in many a debate on the evolution of humans. Along with a few associates, he founded a club—a coterie of 'gentlemen assassins of other people's prejudices'. It was at a meeting of this club that Huxley coined the word that defined his attitude towards religion. One of the members had remarked, "Most of us are atheists. We know there is no God."

To which Huxley immediately retorted, "As for myself, I am merely an agnostic. I don't know." He later added whimsically, "I have been providentially saved from a life of sin by three unorthodox factors—Carlyle, science and love. The philosophy of Carlyle has taught me that a deep sense of religion is quite compatible with the entire absence of theology. Science has given me the support of authority without dogma. Love has opened up to me a view of the sanctity of human nature."

In his final years, Huxley the agnostic found himself being exalted into a saint. The *piece de resistance* came when he received a honorary degree of Doctor of Laws from the citadel of British orthodoxy—the University of Cambridge. But his wit and sarcasm had not left him. "The only ambition that remains in me," he said, "is to become the Archbishop of Canterbury!" That didn't quite take place, but he was soon knighted. He did accept the honour but called 'ancestral nobility' a farce. Tongue-in-cheek, he made a rather wry remark, "My zoological studies have carried me so far back to my rather remote ancestors that my immediate ancestors no longer interest me."

Huxley's health suddenly started deteriorating in his sixtieth year. He resigned from his professorship and his inspectorship at the Department of Fisheries. And finally, with a heavy heart he gave up his greatest honour—the presidency of the Royal Society. In a touching speech he explained to the members that in view of their kindness,

he could not consider holding on to the position for "even a single moment after my reason and my conscience have pointed out my incapacity to discharge the serious duties of this office." When he finished his speech amidst thunderous applause, he turned to his friends and said sotto voice, "I have just announced my official death."

IBN KHALDUN
Psychologist (1332-1406)

One of the intellectual giants of his time, Ibn Khaldun was an obscure figure until the 19th century when Western scholars discovered the relevance of his work on the science of human behaviour. Ibn Khaldun was one of the first positivists, and he systematically elaborated how topography, demography and economic factors act as sociological determinants.

One of the most fitting tributes to Ibn Khaldun's work is given by Philip Hitti in *Makers of Arab History*. Hitti wrote: "The philosopher was born at the wrong time and in the wrong place. He came too late to rouse any response among his people deep in medieval slumber, or to find a would-be translator among Europeans. He had no immediate predecessors and no successors. No school of thought could be styled Khaldunic. His meteoric career flashed across the North African firmament leaving hardly a glare behind."

IBN SINA, ABU ALI
Physician (980-1037)

A precocious genius whose work spanned vast areas of knowledge, Ibn Sina was a reputed physician of his time. He is most well known for his magnum opus, *The Canon of Medicine* (*Al-Quanun*), which until the birth of modern medicine, remained the standard text in the world of

medicine. Ibn Sina however acquired a reputation for hearsay and was declared by theologians of the time to be a blasphemist.

Ibn Sina's approach to life and his commitment to Islam was anything but conventional. To him, religion and science were perfectly compatible and there was nothing contradictory in being committed to both. What really enraged his contemporaries was his open declaration of his unique 'revitalisation' technique, that he wrote about: "If a (scientific) problem was too great for me, I retreated to the mosque and prayed, invoking the creator of all things until the gate that had been closed to me was opened and what had been complex became simple. Always, as night fell, I returned to my house, set the lamp before me and buried myself in reading and writing. If sleep overcame me or I felt the flesh growing weak, I had recourse to a beaker of wine, so that my energies were restored."

For a time Ibn Sina was Vizier to the Emir of Hamadan. Insisting on the primacy of reason, he got into an argument with some of the officers in the Army who happened to be staunch believers. They soon called for his execution and sent soldiers to his house to have him arrested. Ibn Sina was expecting something like this and had fled a few days earlier to the house of his friend Abu Said Dafdaq, where he hid for several months. Although Ibn Sina's house was plundered and all his papers and books burned, he produced a masterpiece, while he was in hiding, in none other than the *Al-Quanun* which was to remain the classic medical reference work for the world, for long after he had died!

Ibn Sina fled persecution and the wrath of the rulers several times. His books were banned and his life was under constant threat. However, when his friends advised him to tone down his views, he replied, "I prefer a short life with depth to a narrow one with length," and continued his work undaunted.

Later, defending his commitment in a famous poem, he wrote:

It is not so easy and trifling to call me a heretic,
No belief in religion is firmer than mine own.
I am the unique person in the whole world if I am a heretic,
Then there is not a single Musalman anywhere in the world.

JOLIOT, FREDERIC
Physicist

Joliot, with his special ability as an experimentalist, chose to concentrate on physics and not chemistry. His professor Dr Langevin, after his graduation advised him to work for Madam Curie at her Radium Institute. He appeared before Madam Curie, trembling in his shoes. Madam Curie asked him, "Can you start work tomorrow?"

Joliot replied, "I am working in military service and I have to finish my assignment within three weeks."

Madam Curie asked him, "What is the name of your Colonel? Let me settle the matter with him."

Joliot reported to work from the very next day. He married Madam Curie's daughter Irene during this assignment. The Joliot-Curie couple discovered 'artificial radioactivity' and for their unique achievement, earned the Nobel Prize in chemistry in the year 1955 when Chadwick earned the Nobel Prize in physics for his discovery of the neutron. During the Great War when France was under enemy occupation, most of the academy staff of the university left Paris. Irene with her two children also left for Switzerland, but Joliot continued as professor in the university in France. After the war he was appointed Chairman of Atomic Energy by Charles de Gaulle. It was therefore no surprise when Charles de Gaulle ordered a state funeral for Joliot which was attended by most of the French people.

KAPITZA, PETER LEONIDOVICH
Physicist (1894-1984)

Russian physicist, who was awarded the 1978 Nobel Prize for physics, for his pioneering inventions and discoveries in the area of low-temperature physics, *cryogenics*, began his scientific career in the electromagnetic department of the Petrograd Polytechnical Institute. In 1921, he came to the Cavendish laboratory at Cambridge to work with Ernest Rutherford and made significant discoveries in magnetism, viz. the effect of very strong magnetic fields on the properties of metals. Kapitza turned to low temperature research in his last years at Cambridge and continued the work after his return to Moscow in 1934. Not much of the episode was ever revealed, but when Kapitza went to Moscow in 1934, it was with the intention of presenting a paper on his work at the Cavendish laboratory. However, upon arrival at Moscow airport, he was arrested and his passport impounded. Thereafter, Kapitza had no choice but to stay on in Russia. To his credit, he managed to continue his research in cryogenics and established the Institute for Physical Problems. His persecution by the Stalin regime didn't end there. He was placed under house arrest and many of his activities severely curtailed between 1946 to 1954. The reason was his refusal to work with nuclear arms.

Kapitza began a series of experiments to study liquid helium that led to his discovery of the superfluidity of helium in 1937. Late in the 1940s, he turned his attention to inventing high-power microwave generators, and discovered a new kind of plasma. Kapitza received eleven honorary degrees and was elected to full and honorary membership of innumerable institutions. He was also a member of the Pugwash movement of scientists for peace.

In 1933, while Kapitza was still at Cambridge, he was asked by Rutherford to arrange for a facade for their new laboratory. Kapitza chose the facade to be adorned with a crocodile chiselled in stone by the well-known

British sculptor Eric Gill. At the offficial inauguration, Kapitza was asked why he had chosen a crocodile as the motif. He replied with a characteristic twinkle in his eyes, "Well, mine is the crocodile of science. The crocodile will not turn its head. Like science, it must always go forward with all-devouring jaws."

KELVIN, LORD WILLIAM THOMSON
Physicist (1824-1907)

This British physicist and inventor was one of the most influential intellectuals of the Victorian age. He had more than 660 publications, touching on every significant area of 19th century physics. He also held over seventy patents, related mainly to telegraphy, electrical measurement and marine navigation. He is best known, however, for his contributions to the subject of thermodynamics and submarine telegraphy.

William Thomson was initially trained as a mathematician and while at Cambridge, published a dozen original publications in theoretical physics. Apart from that he rowed in the college races and founded the University Musical Society. His first important work was in

Paris in 1845 on the theory of electricity, where he derived some crucial equations for many of Faraday's ideas, thus laying the foundations for a mathematical theory of electricity and magnetism. While in Paris, he also discovered Carnot's theory on the motive power of heat which led him to formulate, upon his return to Glasgow, the important concept of an absolute temperature scale, that now bears his name. In 1854, he was appointed Director of the Atlantic Telegraph Company and he frequently sailed aboard the cable-laying vessels in 1865 and 1866. After the cable was successfully laid, Thomson received a knighthood and within a few years, royalties on some of his telegraph patents made him a wealthy man.

In 1867, along with P.G.Tait, he wrote the famous *Treatise on Natural Philosophy*, the most influential physics text-book of the century. In 1892, Queen Victoria raised him to the peerage of Lord Kelvin, a name he took from the Kelvin river, which flows near the University of Glasgow.

Thompson was always a better researcher than he was a lecturer. In recognition of his great scientific achievements, the title 'Lord Kelvin' was to be conferred on him. He therefore asked his assistant Mr Day to take over his teaching assignments during his absence. Mr Day incidentally was an excellent teacher. Returning after the ceremony, Lord Kelvin resumed his teaching. As he stepped into the classroom he found the students in a hilarious mood. Turning to the blackboard, he found a biblical reproof, slightly modified, scrawled in bold letters, "Work while it is day, for the knight cometh when no man can work."

As a professor, Lord Kelvin was mercurial. "Let's put an end to the reading of stale essays," he would say. His classroom and laboratory were full of all kinds of gadgets. In one corner, suspended from the ceiling, was a rubber-covered metal ring with which he used to demonstrate the nature of a dew-drop. One day during a

class, he started pouring water into the ring till it bulged downward dangerously. But Kelvin wouldn't stop. He continued pouring water till the rubber finally burst like an 'over-burdened dew-drop', right over the heads of his students. A quick-witted Lord Kelvin retorted, "I like my illustrations to soak in."

Lord Kelvin had mastered thermodynamics, not only in the outer atmosphere, but also in his own body. He considered life to be "all a matter of temperature" and wore a woollen vest "as a sort of thermostat to regulate the temperature of the body". Whenever he felt cold, he used to put on eight or nine vests and remove them one by one, when he began feeling warmer. His principle, in his own words, was: "To every man his proper vest—to suit his time and temper best."

Lord Kelvin was greatly prejudiced against "the muddled human system of weights and measures". Once he was getting ready with some of his students to shoot at a swinging pendulum. He asked one of his assistants to load the rifle with a dram of gun-powder, referring to the 'avoirdupois' dram measure. But his assistant misunderstood it to be the apothecaries one, which incidentally is twice the other. Kelvin took careful aim with the overloaded gun and was just about to press the trigger when he realised his assistant's mistake. The powder was enough to blow off the heads of all those present there. "I have always been suspicious of the words and works of the human mind," was his only caustic comment.

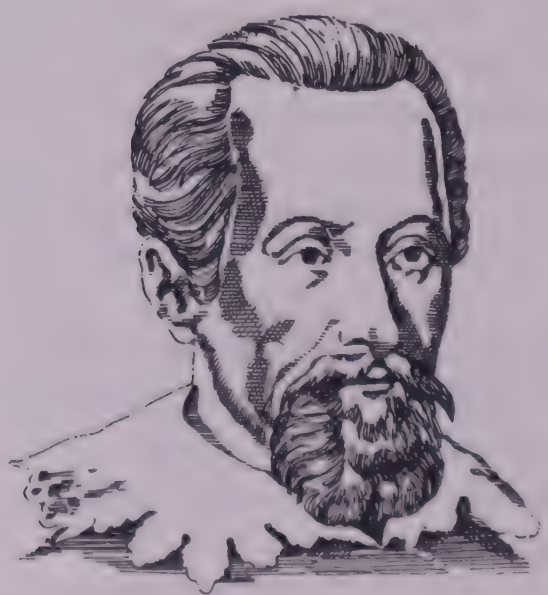
Lord Kelvin's capacity for work grew with age. "A second is too short, we must have longer units," he would complain. When he dictated notes, he would have three or four secretaries surrounding him, each one taking notes on a different subject. He would keep giving orders, shouting excitedly and gesticulating wildly until his parrot Dr Hookbeak would shout from its cage, "Lord Kelvin, Lord Kelvin, shut up."

Lord Kelvin left his professorship at the age of

seventy-six. But he did not leave the university. At the beginning of that academic year, an old man walked into the registration room along with a crowd of undergraduates and signed on the register, 'Lord Kelvin—research student'.

KEPLER, JOHANNES
Astronomer (1571-1630)

Kepler was a German astronomer whose studies of the motions of the planet helped lay the foundation of modern astronomy. After completing his studies at the University of Tubingen, he became professor of mathematics at Graz, in 1594, where he also lectured on Virgil (Roman poet) and rhetoric. Kepler presented an ingenious concept in his first book, *Mysterium Cosmographicum*, in which he said that between the spheres of the six planets, there could be fitted five regular geometrical solids. He believed he had discovered a basic order underlying the distances of the planets from the sun. The year 1600 marked Kepler's momentous meeting with his contemporary Tycho Brahe, in Prague. Following Brahe's death, he consolidated his monumental work on Mars and developed his



three famous planetary laws that transformed the science of astronomy.

Johannes Kepler's grandfather was said to have been of noble blood, although this is difficult to believe from the record of all the members of the family—Johannes' father was a mercenary adventurer who narrowly escaped the gallows; his mother Katherine, an innkeeper's daughter, was brought up by an aunt who was burnt alive as a witch; and Katherine herself, accused in old age of consorting with the devil, had a narrow escape from the gallows! Johannes had six brothers and sisters, out of whom three died in childhood. Johannes' brother Heinrich gained considerable notoriety at the time, as a result of all his misadventures. He was frequently bitten by animals, nearly drowned and nearly burnt alive. He was apprenticed to a draper, then a baker, and finally he ran away from home when his father threatened to sell him!

Kepler himself was a very sickly child, with thin limbs and a face that was too large. He suffered from chronic problems of the stomach and gall bladder and chronic piles, which made him unable to sit for any length of time. At times, Kepler kept walking up and down the whole day. Moreover, he was born with defective eyesight, acute myopia plus multiple vision, and he saw the world sometimes doubled and at other times, quadrupled. Yet he became the founder of modern optics and invented the modern astronomical telescope. In fact the very word *dioptres* is derived from the title of one of Kepler's books!

Kepler's misfortune plagued him all his life. Before his journey to Wuerttemberg, Kepler's friends in Gratz had found a prospective bride for the young man—the daughter of a rich mill-owner, twice widowed at the age of twenty-three. After nine months, their first child was born who died two months later of cerebral meningitis. The next one, a girl this time, died of the same disease.

His wife lived to be thirty-seven and died with a distraught mind. Kepler maintained that he had expected nothing else from the marriage except calamity as the horoscopes he had seen had predicted!

KOCH, ROBERT
Bacteriologist (1843-1910)

The life history and achievements of Dr Robert Koch make a fascinating story in the annals of medicine. The evening of 24 March 1882 marked an important milestone in the history of medicine in general and of tuberculosis in particular. That evening, at a meeting of the Physiological Society in Berlin, attended by distinguished scientists and doctors, Dr Robert Koch presented his well-worded paper announcing the discovery of the organism that caused tuberculosis.

Robert Koch was born on 11 December 1843 at Clausthal, in the beautiful Harz mountains of Germany. His father was a mining engineer and Robert Koch was the third of thirteen children. He had his early education in the local gymnasium, after which he went to Gottingen for the study of medicine. Koch graduated in medicine with honours in 1866, after which he briefly worked at Gottingen University. He also had the opportunity of working under such famous teachers as Ludwig and Virchow. Thereafter, he started private practice in his native village, but subsequently he worked in a hospital in Hamburg. Later, Koch worked as a military surgeon during the Franco-Prussian war.

His experience as a district medical officer in Woolstein, where his duties included reporting on epidemics and epizootics and vaccination encouraged him to undertake research. With the help of a microscope presented by his wife on his birthday, he set up a small laboratory in his house. One historian commented that Koch used his kitchen-table as his laboratory bench and

the pots and pans meant for cooking his food, for making food for the bugs he was cultivating. The first discovery made by him consisted of cultivation of anthrax bacilli. Ferdinand Cohn, professor of botany at Brestan, his teacher and friend was impressed by the quality of his work and is said to have remarked to his students, "Leave all your researches, all of you, and go to see Koch's demonstrations. This man has accomplished a great thing, which...merits the highest appreciations from us all." Koch also demonstrated his findings to his old teacher Virchow, in Berlin. Unfortunately he got a very hostile reception and thereafter, the two great men remained enemies throughout life.

The discovery of Koch relating to anthrax bacilli marked a turning point in his life and he was soon absorbed in the Imperial Health Institute in Berlin as its Director and at the age of forty-two he was appointed professor of hygiene and bacteriology at the University of Berlin. In 1876, he visited Egypt and India as head of the German Cholera Commission. He was awarded 1,00,000 Marks by the Prussian State. Then in 1896 he carried out investigations on rinderpest in South Africa and also made studies in Texas fever, black water fever, tropical malaria and plague. He continued his work, winning laurels all along, culminating in award of the Nobel Prize in 1905.

As regards his personal life, he married, in 1876, a woman called Emily Fraatz, a friend of his childhood in Clausthal. In the beginning it was a very happy marriage and he had a daughter from this marriage in 1868. In 1890, he bought his parental home in Clausthal. However in 1897, after twenty-one years of married life, the relationship broke down resulting in divorce. While some say that his wife felt neglected and decided to divorce him owing to his obsession with bacteriological research, others say that he had started an affair with a young actress which precipitated divorce. Two months after divorce, Koch married Fraulein Freiburg, the young actress

at the age of fifty while the lady was only twenty-one. The second marriage was followed by unwarranted social boycott which forced him to spend most of his time in travelling abroad. He visited Japan, Egypt, India, Indonesia, Africa and other countries mainly with a view to studying diseases caused by bacterial infections and attempting to isolate the organism which caused them. Koch died in March 1910 following a heart attack.

The revolutionary findings of Dr Koch were lauded by scientists all over the world. It is of special interest to note some of the observations made by Elias Metchnikoff, another great scientist who discovered phagocytosis, about the contribution made by Dr Koch to medical science. In his book entitled *Founders of Modern Medicine: Lister-Pasteur-Koch*, Metchnikoff stresses that all the progress in treatment and control of infectious diseases upto that time had been achieved as a result of the contributions of Pasteur and Koch. According to him, "The technique developed by Koch offered the opportunity of discovering the entire world of the organisms causing infectious diseases...the situation has changed drastically after Koch discovered the cholera-vibrio." Describing Koch's visit to Paris, Metchnikoff commented that the former showed his knowledge and good taste in art. In general he appeared to be not just an expert in his narrow field but was well read in different fields of knowledge.

The respect shown by Metchnikoff to Koch and the admiration with which he has spoken of Koch, especially keeping in view the fact that Koch had cold-shouldered him when initially he wanted to show his preparation to Koch, is a shining testimony of the real calibre of Koch. John M. Grange and Patrick J. Bishop of Brompton Hospital, London, in their article published in March 1982 issue of *Tubercle*, the international journal on tuberculosis, wrote that Koch was a most thorough man in all his undertakings and that the acceptance of Koch's discovery was helped by the high esteem in which he was

already held and by his reputation for technical thoroughness. A leading article in *British Medical Journal* appearing on 29 April 1882, stated, "He (Koch) is a worker in whose observations and accuracy the most implicit reliance can be placed and those who have had the pleasure of seeing him at work will hesitate before they find fault with his statements."

Experience shows that throughout the history of science, new ideas, theories or discoveries have always been received with great scepticism, outright rejection and even hostility. The discovery of the tubercle bacillus was no exception. Fully aware of his general apathy and inherent feelings of jealousy in humans, Koch himself felt that it will take at least two generations for his formulations to be accepted completely. However, recognition of Koch's work was amazingly rapid and he was fortunate to experience acceptance of his ideas during his lifetime.

LALANDE, JOSEPH JEROME LE FRANCAISE DE
Astronomer (1732-1807)

Lalande was a French astronomer, who is best known as populariser of astronomy. He published, in 1759, a correct edition of Halley's tables, with a history of the celebrated comet whose return in that year he had helped A.C. Clairaut to calculate. In 1762, he became professor of astronomy in the College de France, where he stayed for forty-six years. His house was an astronomical seminary and among his pupils were Delambre, Piazzi, Mechain and his own nephew Michel Lalande. The Lalande Prize, instituted by him in 1802, for the chief astronomical performance of each year, still continues.

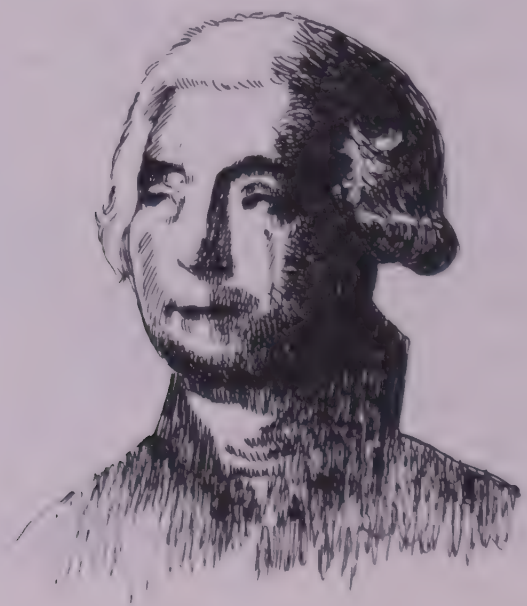
During the 'reign of terror', Lalande confined himself to the study of science, without moving out at all. Later, when someone asked him how he managed to escape the fate that befell so many scientists during the

terrible period, Lalande replied, "I must thank my stars."

LAVOISIER, ANTOINE LAURENT
Chemist (1743-1794)

Lavoisier the French chemist, economist, and public servant is noted especially for his discovery of the role of oxygen in combustion. After an education in mathematics, physics and astronomy, Lavoisier studied law and in the years 1763-1767, he accompanied the noted geologist Jean-Etienne Guettard on geological expeditions in northern France. He published three papers upon his return on the chemical nature of gypsum, a study of ways to improve the street-lighting of Paris, and a study on mineral water. These got him elected to the Royal Academy of Science in 1768.

In 1777, he showed that nitric, sulphuric and phosphoric acids contain 'eminently respirable air'. Lavoisier accordingly named the gas oxygen, from the Greek word for 'begetter of acids'. Lavoisier also showed that in respiration, oxygen is consumed and carbon dioxide given off. In 1783, he began a series of experiments with the mathematician Laplace that supported the theory that respiration is slow combustion.



In 1787, Lavoisier and his colleagues brought out a cooperative work, *Method of Chemical Nomenclature*. Two years later, he published his classic work, *Elementary Treatise of Chemistry*. Lavoisier was also a master of finance and was consequently appointed Director of the Discount Bank. During the French revolution, he published a report on the state of French finances and a classic statistical study of the economic resources of the country. He also played an important part in devising the metric system of weights and measures.

On 27 January 1791, Lavoisier was subjected to a bitter and virulent attack in a French newspaper. The reason given was that years earlier he had dared to give his frank opinion on a fraudulent scientific treatise written by a man who was now the editor of the paper. Lavoisier paid little attention to the defaming article, dismissing it as "the outburst of wounded pride". However before long, Marat the editor, was joined by a number of other radicals who passed a decree to have the Academy of Science closed down. When Lavoisier, Director of the academy, denounced the decree, he was promptly arrested. From there, on the ridiculous charge of "plotting with foreign nations", he was condemned to death.

"I have lived a reasonably long and happy life," wrote Lavoisier from his prison cell. "I shall be spared the inconvenience of old age, and I shall leave behind me a little knowledge and perhaps a little glory. What more can one expect in this world?"

In December 1793, Laovoisier was imprisoned on fraudulent charges, tried, convicted and executed on 8 May 1794. The story is told that Lavoisier appealed at his trial for time to complete some important scientific work, but the presiding judge replied, "The republic has no need of scientists."

Lavoisier was to be guillotined on May 8 morning in 1794. Just before the final moment he wrote a small note to his wife: "Take care of your health, my dear, and

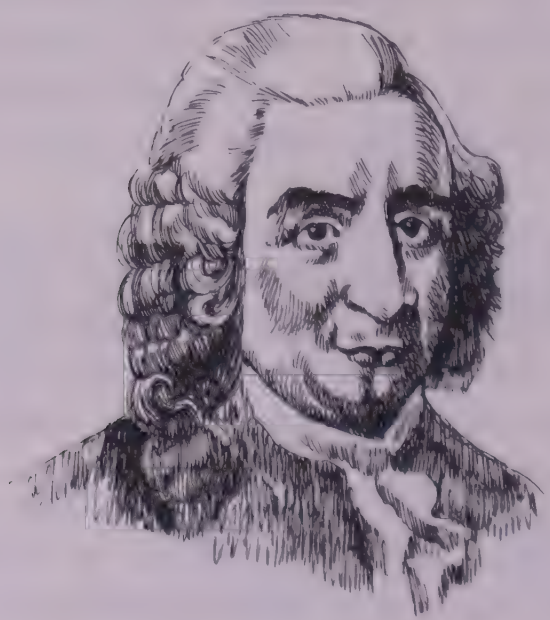
remember that I have finished my work. Thank God for that."

As he was led away, Joseph Louis Lagrange remarked to Delambre, "Only a moment to cut off his head, and perhaps a century before we shall have another like it."

LINNAEUS, CARL
Botanist (1707-1778)

The Swedish botanist and physician, who pioneered the nomenclature system in biology and provided ways to handle and organise systematic information, studied botany in the Netherlands, which at that time was the centre for botanical studies in Europe.

In 1735, he obtained his M.D. from the University of Harderwijk and in the same year introduced the concept of binomial nomenclature for plants in his work, *Species Plantarum*. Three years later, he applied the concept to animals in *Systema Naturae*. His coding system replaced the earlier system of descriptive names by a binomial name, consisting of a Latin or Greek generic name followed by a specific epithet. Linnaeus returned to Sweden in 1738 and established himself in Stockholm as a



practising physician and professor of botany at the University of Uppsala.

In the same year that he published his *Systema Naturae*, Linnaeus had a fortuitous meeting with a certain George Clifford, an extremely wealthy Amsterdam banker. Clifford hired Linnaeus to be his personal physician and to describe his collections of plants and animals on his enormous estate, de Hartecamp, near Haarlem. Linnaeus spent two years at the estate, not only producing a folio—*Hortus Cliffortianus*—describing all the plants in Clifford's garden, but also finished and published all the manuscripts he had brought with him from Sweden!

In the early years after he published his new nomenclature system, Linnaeus was often ridiculed on his work. Baron Georges Cuvier, for instance, refused to acknowledge the importance of Linnaeus' pioneering work by exclaiming, "What difference does it make what you call them? The business of a scientist is to understand, not to name."

Few people outside his native Sweden had heard of Linnaeus even after the publication of his *Systema Naturae* in 1735. Three years later, he visited the Jardine des Plantes in Paris, where the noted French botanist Bernard de Jussieu, was lecturing on rare plants. In the course of his lecture, he came across a plant he had not yet identified. Wanting to help him out, Linnaeus spoke from the audience, "*Haec planta faciem Americanum habet.*"

The professor stared for some time at the figure in the audience and said slowly, "Are you, by any chance, Linnaeus?"

"I am, Sir," replied the Swedish naturalist.

Forgetting his lecture, Bernard rushed up to Linnaeus and warmly embraced him.

LISTER, LORD JOSEPH
Surgeon (1827-1912)

Lister was a British surgeon, who was responsible for the

development of antiseptic surgery. Lister received his medical degree from University College, London and became professor of surgery at Edinburgh and later at King's College Hospital. At that time surgical complications such as gangrene, pyaemia and erysipelas were common. Taking the cue from Louis Pasteur's work on micro-organisms in fermentation processes, Lister predicted that minute germs also cause infections and so went on to develop techniques of antiseptic surgery. This slowly gained acceptance in England and the United States. Lister helped establish the British Institute of Preventive Medicine in 1893, which was renamed the Lister Institute after his death.

Lister struck upon carbolic acid as being a disinfectant that would prevent all the post-operative problems of infection that were so rampant earlier. He introduced a somewhat complex system involving carbolic acid dressings, the cleansing of instruments and ligatures in carbolic solutions, and finally, spraying the air around the operating table with the acid, which amused his staff as the process involved Lister jumping up and down around the table!

William Fergusson was perhaps the greatest surgeon of early 19th century in England. Though a contemporary of Robert Lister, they were poles apart. Once, in the operation theatre of King's College Hospital in London, Fergusson performed an operation that was loudly applauded by the select audience present. Like a seasoned professional actor, Fergusson acknowledged the applause by repeatedly bowing before the gathering. Some days later, Lister did a similar operation, "with more than his usual speed and dexterity", and received an even greater ovation. In response, he only silenced the gathering, saying sternly, "Gentlemen, gentlemen, remember where you are...this is an operation theatre, not *that* theatre!"

Lister was the first physician to be elevated to the

House of Lords, as Baron Lister of Lyme Regis. The honour was bestowed upon him by Queen Victoria, who happened to be a former patient of his.

LORENZ, KONRAD
Zoologist (1903-)

Lorenz, the Austrian zoologist and founder of modern ethology, promoted the comparative zoological study of animal and human behaviour. Lorenz received his M.D. in 1928, and his Ph.D. in 1933, both from the University of Vienna. In 1950, he founded a comparative ethology institute in the Max Planck Institute in Bildern. He began his scientific work by elaborating and applying earlier concepts of animal behaviour to his own detailed observations of the behaviour of several animals. His more recent research involves the genetically based abilities of particular species to learn specific things. Lorenz has developed and inspired concepts relating to genetics, physiology, evolution of behaviour in species. His books, *Man Meets Dog*, *King Solomon's Ring* and *On Aggression* have been widely acclaimed.

Statistical records show that geese pair for life. However, Konrad Lorenz found that there were also quite a few broken partnerships among these birds. When he commented on this, his assistant Helen Fisher promptly retorted, "Well, what do you expect? After all, geese are only human."

Lorenz was once conducting an experiment in auditory stimuli. He uttered a few duck-like quacks near a newly-hatched clutch of mallards to discover that they promptly followed him wherever he went. One day, he was waddling and quacking away when a group of tourists suddenly appeared and looked over the fence. His behaviour must have seemed all the more incomprehensible as the ducklings were all well hidden in the tall grass!

MAHALANOBIS, P.C.
Mathematician (1893-1972)

The Vishva-Bharati at Shantiniketan in Calcutta was formally inaugurated as a public institution on 22 December 1921 with Rabindranath Tagore as founder-president and his son Rathindranath Tagore and P.C. Mahalanobis as its secretaries. Mahalanobis had a very big hand in drafting the first constitution of the Vishva-Bharati which was not changed till the new constitution of the Vishva-Bharati University was framed. He was its secretary for about ten years and helped considerably in organising its work and placing it on a firm foundation.

MARGULIS, LYNN
Microbiologist (1940-)

American microbiologist and co-author of the modern Gaia theory with Sir James Lovelock, Lynn Margulis is one of the youngest women ever elected to the American National Academy of Sciences. She was recently named in a *Newsweek* cover story as one of the top twenty-five American innovators. She is an accomplished microbiologist who believes that the best way to understand the mechanisms and effects of life's continuous pressure on

the environment is to study micro-organisms in their most fundamental microbial form.

For a woman who is clearly ahead of her time, Lynn Margulis had a conventionally early marriage and at the age of twenty-two, had a son and was pregnant with a second child. She followed her husband, the famous Carl Sagan, to the University of California and enrolled in the doctoral programme on genetics. Soon, however, her world took a turn as she began challenging the works of Darwin and Mendel, with very little support from her male colleagues. Her marriage broke up and she had two children to support and an exciting hunch about what she thinks is the universal characteristic of intra-cellular symbiosis. Working late at night, after the children had fallen asleep, Margulis blazed a new trail in microbiology.

MAXWELL, JAMES CLARK
Physicist (1831-1879)

Maxwell was a Scottish physicist, who is remembered for his research in electricity.

Maxwell was born in a well-known Scottish family and was educated at Edinburgh University and Trinity College, Cambridge. After being professor of physics and astronomy at King's College, London, he was given the chair of experimental physics at Cambridge, and it was under Maxwell's supervision, that the legendary Cavendish laboratory was constructed. Maxwell's electrical theory appeared in 1873 in his *Treatise on Electricity and Magnetism*, which is recognised as one of the great monuments of scientific writing. Among his other writings are, *Theory of Heat* and *Matter and Motion*.

James Maxwell entered Cambridge at the age of eighteen, where he worked hard for his degree. He was also famous for his strange theories, especially the one relating to sleeping habits. Maxwell would sleep from 5

to 9:30 p.m., study from 10 to 2 a.m., exercise by running through the corridors and up and down the staircase from 2 to 2:30 a.m., and sleep again until 7 a.m. The other residents were merely stunned initially, but when the young Maxwell persisted in this uncommon routine, he was greeted by a barrage of shoes and other flying objects when he ran past rooms, bringing his theory to an abrupt end!

James Maxwell was a born scientist. To the utter astonishment of his family, he started making his own scientific toys at the age of seven! At the age of fourteen, he wrote a paper on a new method of constructing perfectly oval curves. Such was the impact of the paper that it was read out to the members of the Royal Society of Edinburgh by James Forbes!

Maxwell was showing his scientist friend Kelvin a particular optical experiment. Kelvin, on looking through the eyepiece, seemed satisfied with the phenomenon but asked Maxwell why he was observing a human figure dancing about. Maxwell asked him to look again. But again Kelvin observed the same picture and asked, "But, what is the little man there for?"

Maxwell replied, "Just for fun."

Maxwell once asked Isaac Todhunter to look through his apparatus for a mathematical equation, but failed to persuade Todhunter, for he refused by saying, "I have taught this subject for so long that I do not want my ideas to be upset."

McCLINTOCK, BARBARA
Geneticist (1905-)

This American geneticist received the 1983 Nobel Prize for medicine, for her discovery that genes move from one spot to another on the chromosomes of a plant and change the future generation of plants. Barbara McClintock was educated at Cornell University, receiving her Ph.D.

in botany. In 1931, she and Harriet Creighton made a landmark discovery by proving that when two cells of corn are crossed genetically, they also exchange chromosome material. In 1941, Barbara McClintock joined the staff of the Carnegie Institution's Cold Spring Harbour laboratory in New York. In 1944, she began to study what she later called 'transcription genes' or 'jumping genes'.

Barbara McClintock made a discovery in 1944 that a gene could move spontaneously to another part of its chromosome or even another chromosome, which helped explain some baffling genetic changes. However, the scientific community was totally unprepared for such a revolutionary discovery, and she had to wait for more than twenty years before she received any support from her fellow-geneticists. And the Nobel Prize had to wait another twenty years!

Barbara McClintock was seventy-nine when she received the Nobel Prize. At the press conference that followed, she was asked what she intended to do with the windfall of money. To which, she replied wryly, "When I was much younger, I used to say I wanted two things—to own an automobile and spectacles. Now I just want my spectacles."

MENDEL, GREGOR
Botanist (1822-1884)

The Austrian monk, who was the first to formulate the laws of heredity that became the basis for modern genetic science, entered the monastery at Bruno, in Czechoslovakia, mainly because of financial difficulties in his family, and was ordained a priest in 1847. After a rather short and unhappy stint as chaplain of a local hospital, Mendel was appointed teacher at a nearby school. He was later sent to the University of Vienna, where he studied science and mathematics, and although he never passed the

examination for teacher certification, he came back and taught physics and natural history at the Technical High School in Bruno.

Mendel is best known for the experiments he carried out in plant hybridisation, in the monastery gardens. His most successful experiment was with the garden pea. Using elementary statistical methods, Mendel showed that cross-breeding large numbers of distinct varieties of peas yielded simple and repeatable ratios of some simple character, such as height, shape, etc. in their offspring. Mendel presented and published his findings in 1865, but unfortunately it all went unnoticed. He also made other studies of hybridisation, but the pressures of his position as abbot soon forced him to abandon his experiments.

When he was a school-teacher, Gregor Mendel had to appear for an examination at the University of Vienna, in order to secure a permanent appointment in the school. In his first attempt, the examiners failed him with the comment, "He has not mastered this subject sufficiently to qualify as a teacher in the high schools." Disappointed, Mendel went back to his books and several months later, appeared a second time. Again the examiners failed him with the verdict: "This examination paper would hardly allow us to regard the candidate as competent to become

an instructor even in the lower schools." In doing so, the examiners passed judgment on someone who went on to become one of the greatest biologists in history!

Mendel was always a great hit with his pupils. They came to his class, not so much to imbibe his knowledge, as to have a good laugh over his anecdotes. Once when the circus came to town, Mendel took his entire class to have, what he called, 'a chat with the animals'. However, one of these chats proved of a slightly more serious nature for Mendel. In an effort to attract the attention of a group of monkeys, he strayed too close to the bars. And one of the monkeys, a rather huge fellow, snatched off his spectacles. It was with great difficulty and a lot of painful injuries that Mendel could get them back from the monkey. But once he had retrieved them, he had a good laugh with his students, over his 'wrestling match' with the monkey, despite the pain!

It was the evening of 8 February 1865. Gregor Johann Mendel put his round black hat on his head, his heavy black cloak over his shoulders and stepped out of the door of the monastery into the cold wintry air. As he trudged along the icy roads, Mendel tightened his grip on a pouch that contained a sheaf of folded papers. That night he was to read his report on eight years of painstaking research on the growth of plants. He wondered how many in the audience would understand the title of his report, *Plant Hybridisation*, let alone its complex contents. The meeting began and Mendel was invited to the platform to present his findings. As he proceeded, Mendel looked about him to see whether his audience shared the inner excitement he had felt in making these discoveries about the heredity of pea plants. They were only politely listening, tinged unmistakably with boredom. A man leaned towards his neighbour and whispered, "Eight years spent in watching ordinary peas grow—what a waste of time!" When Mendel sat down, there was hardly a murmur of acknowledgment. The secretary called for the

next report. It was to take the world sixteen years after Mendel's death to realise the significance of what he had done; the 'waste of time' was the foundation for the modern science of genetics!

Mendel spent the last few years of his life experimenting with bees. He had attached a mesh cage to the beehives of his monastery, and had placed a lot of bees in the cage. One of the visitors asked him the reason for this segregation. He jokingly replied. "I have put a queen there, together with a number of drones. The queen is choosing a proper husband, for it is just as unfortunate among bees as it is among human beings when a good woman is married to a bad man."

MENDELEEV, DMITRI IVANOVICH
Chemist (1834-1907)

Mendeleev is the Russian chemist who formulated the chemical periodic table, which has remained the most important organising principle in chemistry. Mendeleev studied chemistry at the University of St. Petersburg, receiving his Ph.D. in 1865. He became the professor of general chemistry in 1867 and after two years of teaching inorganic chemistry, introduced his model of the periodic table. In addition to his academic activities, Mendeleev participated in the early development of oilfields in southern Russia and even visited the United States in 1876 to study the petroleum industry there. He resigned from the university in 1890, as a sign of his support for a group of student activists in their unrest against conservative academic policies. After that he was mainly concerned with the Russian industry, particularly in the area of ship-building.

One of Mendeleev's most remarkable personal features was his flowing abundance of hair. The reason for the overgrowth was, apparently, his decision to have a hair-cut only once a year in spring. The story goes that

when he was to be presented at the court of Emperor Alexander 111, His Majesty was curious to know whether the occasion might prompt Mendeleev to break his rule of the once-a-year hair-cut. On the appointed day, the Emperor as well as his court-bearers waited in anticipation for the possibility of having a shorn Mendeleev appear through the doorway. It was not to be. Mendeleev brought his locks to the court.

Another curious trait of Mendeleev was the clothes he wore. He was never seen in anything else for most of his life than a large and baggy jacket without a belt, made of dark grey cloth. The design was, of course, his own creation.

Mendeleev's periodic table began by his arranging chemical elements in the sequence of increasing weights and noting that the chemical properties of the elements were inadvertently grouped into already familiar families. Occasionally, he left a blank space in order to locate the next element in its proper family, and he correctly predicted the properties of the unknown element that would some day be found! During the next fifteen years, the discovery of gallium, scandium and germanium, whose properties matched what Mendeleev had predicted, established the validity of the periodic table. In the 1890s Sir William Ramsay kept searching for two inert gases only because Mendeleev's table had predicted them, and found xenon and krypton whose properties of course matched what had been predicted. The same applied to the working out of the radioactive decay series. The theoretical explanation for Mendeleev's table came a little less than a hundred years later, with Bohr's work on atomic theory!

Mendeleev willingly recognised Lothar Meyer's claim to independent discovery. Once both scientists were asked to speak before the British Association in 1887. Feeling unable to address the audience in English, Mendeleev simply rose and bowed to the group. Meyer then began

his speech by thanking the British scientists for their hospitality. A thunderous applause followed, and fearing lest a wrong impression be made, for he was to talk of the periodic table, he began with the modest words, "I am sorry, but I am not Mendeleev; I am Lothar Meyer."

Mendeleev would never have been who he was had it not been for the determination of his mother. His father was a teacher of arts and literature at a local high school in Siberia. However, he couldn't keep up the job for long, because of his blindness. After that Mendeleev's mother supported the family of nine by running a local glass factory, owned by her brother. When he was fourteen, the factory burned down, his father died and the family became bankrupt. Undaunted, his mother slaved away, sent young Dmitri to Moscow and then to the University of St. Petersburg, convinced that there were seeds of greatness in her boy. Till the end of his life, Mendeleev always quoted his mother's dying words: "Refrain from illusions, insist on work and not on words. Patiently search the divine and scientific truth." And he dedicated his famous book on solutions in her memory to "a woman, who had instructed by example and corrected with love", and who had spent her last resources and strength in providing him with a scientific education.

MILLIKAN, ROBERT ANDREW
Physicist (1868-1953)

This American physicist and educator was awarded the 1923 Nobel Prize for physics for his work on the elementary electric charge and on the photoelectric effect. Millikan studied physics at Columbia University and later taught at the University of Chicago. In 1909, he devised his famous oil-drop experiment for determining the charge of an electron. The experiment was carried out by suspending

two charged metal plates with tiny holes at the top, horizontally. Oil was then sprayed into the space between the plates, and the droplets were then charged. The charge was then measured on the basis of the rate of ascent or descent of the droplets as the voltage between the plates varied. In 1916, Millikan confirmed the photoelectric equation of Einstein with another breathtakingly simple experiment.

When Robert Millikan was still a sophomore student at Oberlin College, he had no intention of ever taking up physics as a subject, let alone a career. One day, his Greek professor asked Robert to teach some elementary physics in the class. Somewhat bewildered, he confessed to the professor that he did not know any physics at all. The professor replied, "You have done excellent work all year in my Greek class; I'll risk anyone who can do what you have done in Greek, to teach physics." Thus began a scientific career for a Greek scholar!

Millikan's wife once happened to pass through the hall of their home in time to hear the maid answer the telephone. "Yes," Mrs Millikan overheard the maid say. "This is where Dr Millikan lives, but he's not the kind of doctor that does anybody any good."

MOND LUDWIG
Chemist (1839-1909)

A new direction to the science of metallurgy, particularly in the case of nickel, was given by this German-British chemist. Mond gained a reputation of being able to work wonders with metals, and had frequent visitors to his workshop who came to see his ingenious techniques on metallurgy.

The celebrated and eccentric scientist had settled in England and introduced one of his most novel propositions: extreme heat and extreme cold produce identical reactions on the skin. To prove its truth, he entered the kitchen holding a long iron rod with a wooden handle. There was a big fireplace that heated the rest of the house. He put the iron rod into the blazing fire until it turned red hot. The old cook, who was kneading the dough, furtively looked across, wondering as to why the master had come into the kitchen. Mond picked up the red hot rod, flourished it above his head to the bewilderment of the woman, and then suddenly when she was not looking, he touched her bare neck with a piece of ice, whereupon she started yelling, "I am burnt, I am burnt...!"

Ludwig Mond's young son Alfred once said, "The nextdoor shop has a beautiful bicycle and I asked the shopkeeper how much it cost. He says it is a penny, so please give me one and I can have the bicycle."

Mond gave him the money and the youngster ran away, only to rush back, saying, "He says this is not the penny that can buy it; it is the penny that has the king's face on both sides."

Mond's only reply was, "We shall see if such a penny exists in my bag." He then went down to his workshop, neatly sliced two pennies and joined the two head sides together and put the oddity in his bag. He then called out to Alfred and asked him to search his bag. Finding the penny, Alfred raced to the shopkeeper, who had no alternative but to sell the cycle to the youngster!

MORSE, SAMUEL FINLEY BREESE
Artist-inventor (1791-1872)

The American artist and inventor, who pioneered the development of the Morse code and the telegraph machine, began painting miniatures on ivory after graduating from Yale in 1810. He subsequently switched over to painting portraits and many of his works are still exhibited at Syracuse University and the Yale University Art Gallery. He was appointed professor of painting and sculpture at New York University and also became the first president of the National Academy of Arts and Design in 1845. Morse was also the first to give a series of lectures on art in the United States.

However, after 1837, his growing interest in the telegraph led to his break with painting and he painted only one portrait after that. With the assistance of Leonard Gale, he constructed a model of a telegraph machine and gave the first real demonstration on 2 September 1837. The most important feature of Morse's telegraph was the use of an electromagnet at the receiver. In April 1838, a bill was introduced in the Congress to grant US $ 30,000 for the construction of a line between Washington and Baltimore. Despite difficulties in insulating the wires, the line was constructed with the aid of Ezra Cornell and the first message was sent by Morse on 24 May 1844, ushering in a new era of long-distance transmission. The message, ironically enough, read as follows: "What hath God wrought!"

Samuel Morse once painted a man in the throes of death and asked a physician friend to take a look. "Well?" inquired Morse after the doctor had scrutinised the painting. "What's your opinion?"

The doctor removed his spectacles, turned to Morse and replied, "Malaria."

MOSELEY, HENRY GWYN-JEFFREYS
Physicist (1887-1915)

Moseley, the British physicist who did pioneering work on spectrum analysis, discovered a fundamental relationship between the atomic numbers of elements and their X-ray spectra. Moseley graduated from Oxford University in 1910 and worked with Lord Rutherford from 1912 to 1914. Moseley demonstrated that his X-ray technique was capable of locating all the gaps in the periodic table that represented still undiscovered elements, seven at the time. His concept of atomic number made it possible to insert the rare earth elements in the places 57 to 71 in the table. Moseley also concluded correctly that there were only ninety-two elements that included uranium.

While working in Lord Rutherford's laboratory, Moseley would often get annoyed with his colleagues for borrowing his matches regularly. He finally came up with a solution. He purchased a large carton of match-boxes and put them in an open packing case at the corner of his table. On the case Moseley hung a sign that read: 'Please take one of these boxes and leave my matches alone!'

A year after he had announced his landmark discovery, Moseley joined the British Army and was sent to the front lines. Before leaving, he gave precise instructions to his colleagues about certain experiments to be performed until he returned.

It was most unfortunate that at a very young age the Great War claimed him a victim of a bullet shot at Dardanelles, on the Turkish front, on 10 August 1915. The British government realising that one of the most brilliant brains was in danger on the war front, sent a telegram for his release but it was received after his tragic death. The poet's fancy rarely rides on such an event:

> Beyond the violets seek him, for there in the dark he dwells,
> Holding the crystal lattice to cast the shadow that tells.

How the heart of the atom thickens, ready to burst into flowers,
Loosing the bands of Orion with heavenly heat and power.
He numbers the charge on the centre for each of the elements
That we named for gods and demons, colours and tastes and scents...

Michelson said about this sad event that the European war, which resulted in snuffing out such a young life, should be held responsible for making it one of the most hideous crimes in history.

MULLER, HERMANN JOSEPH
Biologist (1890-1966)

This American biologist won the 1946 Nobel Prize in medicine for his discovery of the production of mutations by X-ray irradiation. Muller studied biology at Columbia University, where after graduation he became a member of T.H. Morgan's prestigious genetic research group. Muller began his genetic experiments with his studies of the fruit fly and demonstrated that X-ray mutations take place as a result of changes within individual genes and chromosome breakage. His discovery had the important consequence that it stressed the necessity of minimising human exposure to radiation of any kind and it also made it possible for scientists to create large numbers of mutations at will. Muller's work also filled one of the last major gaps in the evidence of Darwin's theory of natural selection.

When German scientists, like their Russian colleagues under Stalin, were being persecuted, Muller issued a strong protest in the name of geneticists throughout the world. "Good or bad genes," said Muller, "are not the monopoly of particular peoples or of persons with features of a given kind."

NERNST, WALTHER HERMANN
Chemist (1864-1941)

Nernst was the German physical chemist to be awarded the 1920 Nobel Prize for chemistry, for his work on thermochemistry. Nernst was a professor of physical chemistry at the University of Gottingen and later became Director of the Institute of Experimental Physics at Berlin. Nernst put forward his famous heat theorem in 1906-1907, which came to be known as the Third Law of Thermodynamics. As given by Nernst, the law states that at a temperature of absolute zero, the entropy of every substance in perfect equilibrium is zero. Nernst is also credited with the invention of an incandescent lamp and a piano that had electronic amplification of its sounds.

Nernst once had the honour of demonstrating to the German Emperor and Empress how radio transmission works. The transmitter was in the Institute of Experimental Physics, and the royal couple were sitting next to a receiver in their castle. After a great deal of speculation over what would be appropriate enough to be transmitted, Nernst finally chose a phonograph record of the famous Italian tenor Enrico Caruso. Later in the day, Nernst was invited to the castle. The Empress warmly congratulated him on the successful demonstration, adding, "By the way, good professor, we didn't know that you were such a fine singer!"

NEWTON, SIR ISAAC
Scientist (1642-1727)

Newton was Britain's natural philosopher who is generally regarded as the most original and influential thinker in the history of science. Among his very many amazing achievements are his invention of the calculus, his theory of light and colour, the three laws of motion and the law of universal gravitation. As the son of an illiterate yeoman, Newton had an utterly unhappy childhood.

Once every week, when Newton was a young boy, he would accompany the servant to the market. But when they approached the market, Newton would plead with the servant to allow him to stay behind. "You'll find me here on the way back," he would say. "I shall be studying my books behind the hedge."

One day, Isaac's uncle became suspicious of his all-too-frequent market trips, and followed him to the market. He found his nephew lying on the grass, completely engrossed in some mathematical problem. The old man looked at him gently and said, "Go back to your studies, Isaac. Either you are a great loafer or a great genius—the Lord alone knows which."

Isaac Newton was born prematurely on Christmas day in 1642, 'small enough to fit into a quart pot', a few months after his illiterate father had died. When he was barely three years old, his mother left him in the care of his grandmother, so that she could be free to marry again. He hated his stepfather and longed for maternal love which he never received and his childhood was anything but happy. Throughout his life, he was on the verge of emotional breakdowns, occasionally falling into violent and vindictive attacks on his friends and colleagues.

Being terrible at athletics, Newton once decided to skip a sports meet while at Cambridge. He was, however, forced to participate. It was then that the scientist in him helped him. He noted that a gusty wind was blowing when he entered the field. Newton lost his nervousness, and took, what he described later as "timid leaps to take advantage of the gusts", and won the event.

Newton was once gently holding the hand of a woman he was in love with, looking deep into her eyes. His mind, however, was on the binomial theorem for infinite quantities. Lost in thought, he took the lady's finger to be his pipe-cleaner and started pushing it up the stem of his pipe, which he had just smoked. Only when she cried out in anguish, did Newton realise what he had been doing. Apologising profusely in embarrassment, he excalimed, "This is how I find myself at fault. I find that I am cursed to remain a bachelor."

Newton also had a strange sense of practical values. Once a guest at his house showed him a prism and asked him to ascertain its practical value. Immediately sensing its potential as an object of scientific research, Newton replied, "The value is so great that I cannot even ascertain it." Upon hearing this, the visitor offered to sell the prism to him at an exorbitant price, whereupon Newton immediately accepted the offer. When his house-keeper saw what he had bought, she rebuked him and said, "Why, you silly man, you need only have paid a price according to the weight of the glass!" Newton only shook his head and smiled. That purchase was to lead him to formulate his theory of colour!

Isaac Newton went to Cambridge in 1661, where he became deeply engrossed with the works of Descartes, Euclid, Hobbes and Gassendi. In the two plague years of 1665 and 1666, when Cambridge was closed down, Newton conceived his method of calculus, laid the foundations for his theory of colour and made significant inroads into planetary motion that eventually led to his

classic work, *Principia Mathematica*, in 1687. After this publication, he became involved in public affairs, enjoying power and worldly success. In 1696, Newton was appointed warden and later, master of the mint, and he left Cambridge without regret. In 1704, he published his second classic work, *Optiks* and was knighted in 1705.

In 1678, Newton suffered a serious emotional breakdown, and in the following year his mother died. His response was to cut off all contact with others and engross himself in alchemical research. While the mechanical philosophers reduced all phenomena to the impact of matter in motion, the alchemical tradition upheld the possibility of attraction and repulsion at the particulate level. Newton's later insights in celestial mechanics can be traced in part to his days of alchemy. He transformed the prevailing mechanical philosophy by adding a mysterious quantity—gravitational force.

In August 1684, Edmond Halley paid a legendary visit to Newton in Cambridge, hoping for an answer to the riddle: What type of a curve does a planet describe in its orbit around the sun?

When Halley posed the question, Newton's ready response was 'an ellipse'. When asked how he knew it, Newton replied that he had already calculated it. However, he had mislaid the calculation and promised to work it out again for Halley. What was to result after two years of intense labour was the epic, the *Philosopiae Naturalis Principia Mathematica*!

Robert Hooke, the celebrated curator of the Royal Society's experiments, was Newton's *bete noire*. Skirmish after skirmish followed between the two. However, ironically, it was as a result of Hooke's letters that Newton started working on the law of gravitation. But later, when Hooke claimed that his letters of 1679-1680 had earned him a role in Newton's discovery, it made Newton so furious that he threatened to suppress the third book of his *Principia*, denouncing science as "an impertinently

litigious lady". He eventually consented to its publication but systematically deleted every possible mention of Hooke's name. Newton's hatred for Hooke was so consumptive that he also held up the publication of his *Optiks* (1704) and withdrew from the Royal Society until Hooke's death in 1703! When asked why he hadn't had his work published earlier, Newton replied, "I'll print nothing, for that would only result in attracting acquaintances."

When Newton finally published his *Principia*, it was incomprehensible to most people. A famous philosopher of the time, finding the book too difficult to understand, asked Newton to suggest a preliminary course to study that might prepare him to understand the complex mathematics of the *Principia*. With graciousness, Newton drew up a list of 'necessary books' for the philosopher. These books were themselves so formidable that the philosopher decided to give up, saying, "The reading of the preliminary list alone would consume the greater part of my life."

When he was criticised for making the universe appear lifeless and arid in his theory of gravitation, Newton replied, "The fact that the universe is so beautifully designed in accordance with such harmonious laws...must presuppose the existence of a divine wisdom, the hand of a divine Creator." When asked to clarify what he meant by the last bit, he refused to comply. Instead he replied, "I can frame no hypothesis about Him. I am a scientist and I do not speculate about theological matters. I deal not with God, but with his observable laws."

When he was studying at Cambridge, Newton's housekeeper once came to him and said, "I have bought seven fish at the rate of three pence each. Please tell me how much I should pay the fish monger."

Newton promptly whipped out his logarithm tables, worked out the problem and gave the solution. "The amount should be between twenty and twenty-two pence."

"The man demands twenty-one pence," said the housekeeper.

"What!" retorted Newton, "How did he arrive at that? The fish monger is a greater mathematician. He has got the answer quicker."

Newton used to have a pet dog named Diamond. One day, a sudden movement by the dog caused a burning candle to fall on a pile of valuable manuscripts, that were soon reduced to ashes. These manuscripts were the only record of twenty years of his painstaking research. All Newton did was to stroke the feline gently and say, "Oh, Diamond, you do not know what mischief you have done me!"

The story goes that Newton was so fond of a cat he had that he cut a hole in one of the walls of his house to make it convenient for its entry and exit. One day he saw that she had kittens and in his usual philosophic absent-mindedness, cut out a neat little hole (a much smaller one) for the kittens!

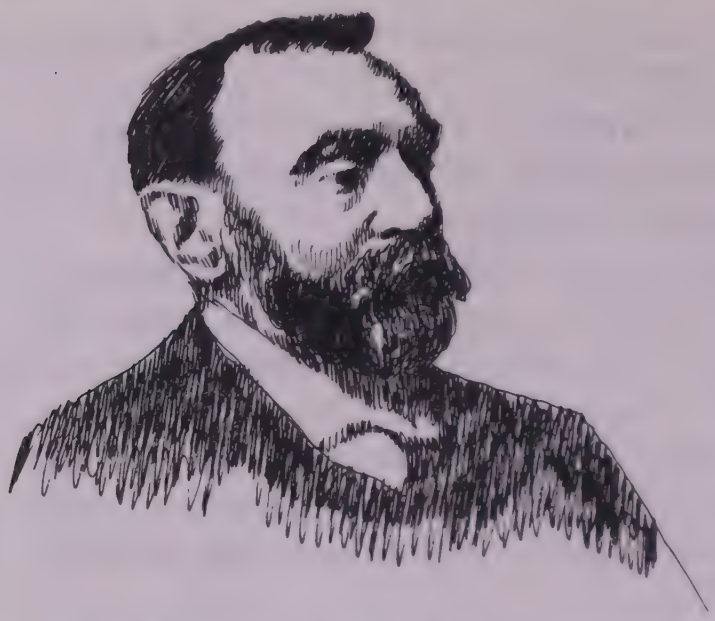
In the later years of his life, Newton became obsessed with establishing himself as a noble gentleman. He once remarked casually to a distinguished Scottish laird, "Do you know, that I too am a Scot? My grandfather was a gentleman of East Lothian...or was it West Lothian? Perhaps it was my great grandfather..."

"Never heard of him," replied the laird bluntly.

Wrote Isaac Newton a short time before his death: "I do not know what I may appear to the world, but to myself I seem to have been only a boy playing on the seashore and diverting myself now and then in finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay undiscovered before me."

NOBEL, ALFRED BERNHARD
Philanthropist-scientist (1833-1896)

The Swedish inventor, who became famous for his



invention of dynamite and other explosives, was the founder of the Nobel Prize. Nobel was never formally educated, but instead received private instruction. He then began work in his father's factory from 1853 to 1859, developing torpedoes and mines. His first successful explosion with nitroglycerine was in 1862, when Nobel set up a small factory near Stockholm for its manufacture. One day, by a fortuitous turn of events, he was delayed in going to the factory. His youngest brother Erik was already there, supervising the manufacturing process. And due to some unforseen accident, the entire factory was blown to smithereens, leaving behind a mass of rubble and smoke! After much modification it was patented as 'dynamite' in 1876.

In 1888, he developed ballistite, a smokeless powder produced from nitroglycerine. Nobel accumulated a vast fortune from the manufacture of explosives, and from oilfields in Russia, which were developed and managed by his two elder brothers. When he died in San Remo, Italy in 1896, he left the major portion of his fortune of $ nine million for the establishment of annual awards for men and women who confer the greatest benefit on mankind in the fields of physics, chemistry, physiology or medicine, literature and peace.

Alfred Nobel was once asked to write an autobiography. He replied that it was impossible for him to do so, as he felt that all there was to be said about himself could be written in the form of a brief police description. And he proceeded to write, what is on record, as the shortest autobiography ever written.

Description: Pitiable half-creature, who should have been stifled by the doctor when he made his entry yelling into the world.

Merits: Keeps his nails clean and is never a burden to anybody.

Faults: Lacks family, cheerful nature, healthy stomach.

Greatest and only petition: Not to be buried alive.

OPPENHEIMER, J. ROBERT
Physicist (1904-1967)

This American physicist is best known as the man behind the development of the atomic bomb during the Second World War. The son of a prosperous textile importer, Oppenheimer graduated from Harvard and then spent the next two years at Ernest Rutherford's laboratory in Cambridge, England and with Max Born in Gottingen, Germany, returning to the United States in 1929. The years between 1943 to 1945 were devoted to war work, at Los Alamos in New Mexico, with the work culminating in the famous atomic test at Alamogordo. He received the Medal of Merit from President Truman in 1946 and thereafter served in many advisory capacities. In 1947, he accepted the directorship of the Institute of Advanced Study in Princeton, a post he held until his death.

Oppenheimer is also remembered for creating a school of theoretical physics at Berkeley, which played a pivotal role in leading to growth of physics in the United States. Although he was no longer active in research during his years at Princeton, Oppenheimer encouraged, inspired

and guided his young colleagues. He also wrote extensively about the problems of the atomic age and the relationship between science and culture.

Robert Oppenheimer had to take piano lessons for a number of years during his childhood, until the day when he was in bed with 'flu. When his mother asked him how he felt, he replied, "Like I do when I have to take piano lessons." That reply abruptly ended the piano lessons.

When Robert Oppenheimer was a professor at University of California, Berkeley, Enrico Fermi was a distinguished guest of honour at the 1940 Hitekoch lectures. Oppenheimer was used to presenting physics in extremely abstract terms, unlike Fermi. After attending a lecture on the subject of beta decay, Fermi said ruefully to physicist Emilio Sergle, "I am getting rusty and old. I cannot follow the highbrow theories developed by Oppenheimer's pupils any more. I went to their seminar and was depressed by my inability to understand them. Only the last sentence cheered me up. It was: '...And this is Fermi's theory of beta decay'."

Robert Oppenheimer once took Melba Phillips, a research assistant, for a car ride on Berkeley hill. He parked his car at a scenic place, made Ms Phillips comfortable by wrapping a blanket around her, and announced that he would be gone for a short walk. Time passed. Policeman Albert Nevin went by. "My escort went for a walk hours ago and he hasn't returned," wailed a distraught Ms Phillips.

A search of the neighbourhood proved fruitless. Then acting on a hunch, the policeman went to the Faculty Club, and found the professor in bed, asleep. "Melba!" he exclaimed on seeing the policeman. "Oh, my word, I forgot all about her. I just walked and walked and I was home and I went to bed!"

Professor Koenig remembered Oppenheimer as "bright and sensitive, but very much in conflict with

himself—the conflict between thought and action." Koenig also said, "For some reason when I think of Oppenheimer, a quote from Goethe comes to mind: 'Thought widens but paralyses; action enlivens but narrows'."

Oppenheimer loved to narrate stories about himself. One of his favourite anecdotes was a conversation in which he and Paul Dirac figured when they were both at Gottingen. Dirac took Robert aside one evening and said, "I don't understand you. In science we try to say things no one has ever said before, in a way that everybody can understand. But in poetry, you say things in such a way that nobody can understand."

Oppenheimer earned the enemity of important officers in the Air Force when the Vista Project, of which he was a member, strongly recommended that tactical nuclear weapons be deployed only to defend the Allies in Europe. This went against the Air Force which wanted massive retaliation. With the coming of the McCarthy era, these enemies saw an opportunity of destroying Oppenheimer. A long trial followed in which he was questioned provocatively about his long-time associations with communist friends, although these relationships had been public knowledge even during Oppenheimer's Los Alamos days. Oppenheimer was found guilty and the security denied him clearance. In 1963, President Kennedy moved to redress the injustice by choosing Oppenheimer for the Fermi award. It was given to him by President Johnson in December 1963, but security clearance was never restored.

When at Berkeley, Oppenheimer met the Sanskrit scholar Arthur Ryder. The two soon became good friends and Ryder taught Oppenheimer to read Sanskrit. It did not take him long to master Sanskrit well enough to read the *Bhagwad Gita*. Of the *Gita*, Oppenheimer said, "It is the most beautiful philosophical song existing in any known tongue."

Once while showing his new car to a friend,

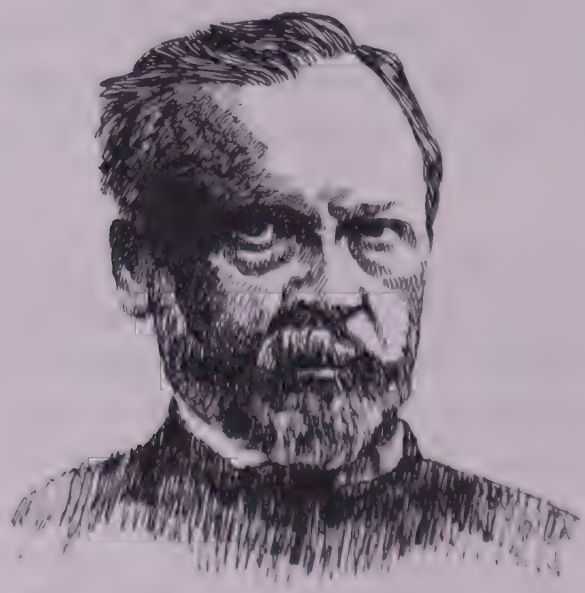
Oppenheimer remarked, "The car's name is Garuda—the vehicle (*vaahan*) of Maha Vishnu."

After the first atomic test, when the blue-violet of the sinister colour vanished, leaving behind an outline of grey smoke splashed with the yellow morning sun, Oppenheimer was to remember a line from his favourite *Gita*, 'I am become Death, the shatterer of worlds'.

PASTEUR, LOUIS
Chemist (1822-1895)

The French chemist and founder of the science of microbiology made one of the greatest contributions to medicine by his discovery that most familiar diseases are caused by germs.

Pasteur received his education at the Ecole Normale Superieure in Paris and served first as professor of physics at Dijon, and then as professor of chemistry at Strasbourg. After that he returned to Ecole Normale as Director of Scientific Studies. In 1888, he became the first Director of the newly established Pasteur Institute. His first discoveries were in crystallography. Pasteur first presented his germ theory in 1857, in which he claimed



that just as in fermentation, diseases were caused by microbes. He then went on to show that in reality each microbe is derived from a similarly pre-existing microbe and that spontaneous generation does not occur, unlike what was earlier believed. He demonstrated that spoilage of perishable products could be prevented by destroying the microbes already present in the products and by protecting the material against further contamination.

In 1865, Pasteur was asked to study diseases of silkworms that threatened the silk industry, and after three years of laborious work, he found that there were two distinct diseases in silkworms, and showed how they could be prevented.

In 1877, he demonstrated that anthrax was caused by a particular bacillus that can survive in the carcasses of dead animals. He went on to found the science of immunity by demonstrating that smallpox could be prevented by injecting cowpox material, thus beginning a new era of vaccination.

Finally in 1882, he showed that rabies was caused by a virus and was able to cure humans who had been bitten by rabid dogs.

Pasteur was the son of a poor tanner. It was with great financial difficulty that he went on to study for his doctorate in chemistry. He had to ration his food and firewood to the barest level possible, and frequently suffered from hunger pangs. In his later years, when he was asked how he could have gone on like that, Pasteur replied, "Fortunately I was also subject to frequent headaches, so one pain tended to cancel out the other."

Pasteur's persistence in love was no less than his persistence in his studies. After having been turned down by the girl he loved, he wrote to the young girl's mother, "I am afraid that Mademoiselle Marie attaches too much importance to first impressions, which can only be unfavourable to me. There is nothing in me to attract a

young girl. But memory tells me that when people have known me well, they have liked me."

It was Pasteur's wedding day. His bride and her family were chewing off their fingernails in panic when he did not show up. The pastor shouted, "Where on earth is that young chemist?"

Where could he be except in his laboratory, thought a friend of Pasteur as he hurried to the lab to see if he was there. The unruffled groom was plunged deep in one of his experiments. "Did you forget your wedding?" asked the friend.

"Oh, no!" replied Pasteur. "But do you expect me to quit in the middle of an experiment?" was Pasteur's rejoinder.

When Pasteur was investigating the silkworm epidemic on request by the government, three of his children died in succession. "To go on persistently with your work under such conditions," remarked a friend, "must require a lot of courage."

"I don't know much about courage," replied Pasteur. "But, I do know my duty."

Once while the Academy of Medicine was discussing Pasteur's principle of immunisation, tempers ran so high that Pasteur called one of his critics 'stupid'. Jules Guerin rushed at him violently, but there was an intervention and the meeting was declared closed. Dr Guerin, in the tradition of the day, challenged Pasteur to a duel. Unruffled, Pasteur reminded him, "Doctor, you know, my business is to heal, not kill."

The most dramatic episode in Pasteur's life came during his famous battle against hydrophobia. His experiments used to consist of inoculating the saliva of mad dogs into healthy rabbits, by allowing them to be bitten by the dogs. On one occasion, a large, ferocious bulldog refused to comply. Pasteur concluded that it would be necessary to suck the saliva out of the dog's mouth and then inject it into the rabbit. His assistants tied the

dog securely, and Pasteur, with a glass tube in his mouth, bent close to the jaws of the animal. Very calmly and fully aware that even a tiny drop of the deadly liquid was enough to kill him, he sucked into the tube. When he thought he had pulled out a sufficient amount, he turned to his assistants and said in a cool voice, "Well gentlemen, we can now proceed with the experiment!"

Pasteur had been elected by the French government to represent the country at the International Medical Congress in London. He entered St. James Hall amidst tumultous applause. Pasteur was, however, blissfully unaware that he was the cause of the ovation. He turned to his escort and said a little hesitatingly, "It must be the Prince of Wales arriving. I'm sorry I didn't come earlier."

Pasteur worked with incredible intensity even after a stroke had partly paralysed him at the age of forty-seven. He continued his research until his health completely broke down. He was, he confessed, guided by a conviction that there were spiritual values that transcended science, that gave meaning to his work.

PAULI, WOLFGANG
Physicist (1900-1958)

Pauli was the Austrian physicist, who was awarded the 1945 Nobel Prize for physics for his ground-breaking work in quantum physics that culminated in his formulation of the famous 'exclusion principle'. Pauli studied at the University of Munich under the renowned Arnold Sommerfield, where he produced a brilliant 250-page essay on Einstein's Theory of Relativity. After Munich, Pauli worked for a while with Neils Bohr in Copenhagen on possible improvements on the prevailing Bohr-Sommerfield structure of the atom. In 1924, Pauli proposed that in addition to the three parameters that specified an electron's orbit, there existed one more, which he termed the 'spin' of the electron. In the following year, he proposed the

exclusion principle, which proved indispensable to the development of the quantum theory as well as nuclear and particle physics.

Equally important was Pauli's prediction of a new chargeless particle of negligible mass, which he called the 'neutrino'. This particle was experimentally detected in 1956. After the war, Pauli's interests turned more philosophical and he collaborated with Carl Jung in the investigation of the parallels between analytical psychology and quantum physics.

Eugene Wigner, the physicist, once reminiscing about Pauli, said, "Pauli was a brilliant lecturer if he prepared his address. Once when I invited him to address our colloquium in Princeton, he was clearly unprepared. The audience began to get restless, and feeling somewhat responsible for the event, I wanted to help out. He had not defined the mathematical symbols he was using and I thought that if he explained them, it would help us understand what he was trying to say. 'Pauli,' I said, 'could you tell us again what your small 'a' stands for?' The 'again' was sheer politeness, for Pauli had never defined it. Pauli was completely flabbergasted by my question and just stood there, speechless for a few sec-

onds. When he had recovered, he said, 'Wigner, you just have to know everything.' Needless to say, the audience did not find that very amusing."

Pauli could be ruthless in his scientific criticism, for he had a profound insight into physics, and his intuition was quick to spot false trails, shaky arguments and errors of assumption. For this reason, the young Pauli was nicknamed *die geissel Gottes* (the whip of God) and *der furchterlichi Pauli* (frightful Pauli). Even Einstein and Heisenberg were not immune from his critical attacks.

In Heisenberg's words, "I spotted a dark-haired student (at the University of Munich) with a somewhat secretive face in the third row. Sommerfield had introduced us during my first visit and had then told me that he considered the boy to be one of his most talented students, one from whom I could learn a great deal. His name was Wolfgang Pauli and for the rest of his life, he was to be a good friend, though often a very severe critic."

And Einstein, after reading Pauli's essay on the Theory of Relativity, wrote: "No one studying this mature, grandly conceived work could believe that the author is a man of twenty-one. One wonders what to admire most—the psychological understanding for the development of ideas, the sureness of mathematical deduction, the profound physical insight, the capacity for lucid systematic presentation, the complete treatment of the subject matter, or the sureness of critical appraisal."

Despite his breathtaking work in quantum physics and the incredible level of sophistication of his scientific thinking, Pauli's own life had begun falling into greater and greater disorder. His lectures at the University of Zurich, where he had been appointed a year earlier, in 1928, were becoming confusing and ill-prepared. In addition, his critical tongue was becoming uncontrollably sarcastic. His mother had poisoned herself, and Pauli's recent marriage to a cabaret singer, broke up violently in a few weeks. Pauli was also drinking heavily and was,

on several occasions, thrown out of bars for physical assault. Precariously close to a complete breakdown, Pauli sought the professional help of Carl Jung, who had this very interesting thing to say about Pauli: "...A university man, a very one-sided intellectual. His unconscious mind had become troubled and activated, so it projected itself on to other men who appeared to be his enemies, and he felt terribly lonely, because everyone seemed to be against him...he made a fool of himself with women and, of course, they had no patience with him..."

Apart from the 'exclusion principle', Pauli had become notoriously famous for the 'Pauli effect'—a phenomenon that has gone down in the mythology of science. The effect concerned Pauli's allergy to laboratory apparatus, or maybe, the other way around—the allergy that lab equipment 'felt' when Pauli was around! It was said that Pauli had only to walk into a laboratory for something to either explode or fracture!

Glasswares would break, needles/apparatus fall, electric wires start sparkling. Such humorous accidents, however, were not taken lightly by a principal of his university, who prevented Pauli from entering his laboratory whenever Pauli visited his university as a distinguished guest.

Many examples of the 'Pauli effect' are still recounted by physicists. Professor J. Franck had a particularly curious one that he frequently referred to. On one occasion, a complicated piece of machinery collapsed in the Gottingen laboratory. Franck wrote to Pauli pointing out that, since the theoretician was living in Zurich, the Pauli effect could hardly be to blame in this case. Pauli, however, replied that he wasn't in Zurich at that time; he was in a train travelling to Copenhagen and the train had stopped at Gottingen station exactly at the time of the mishap!

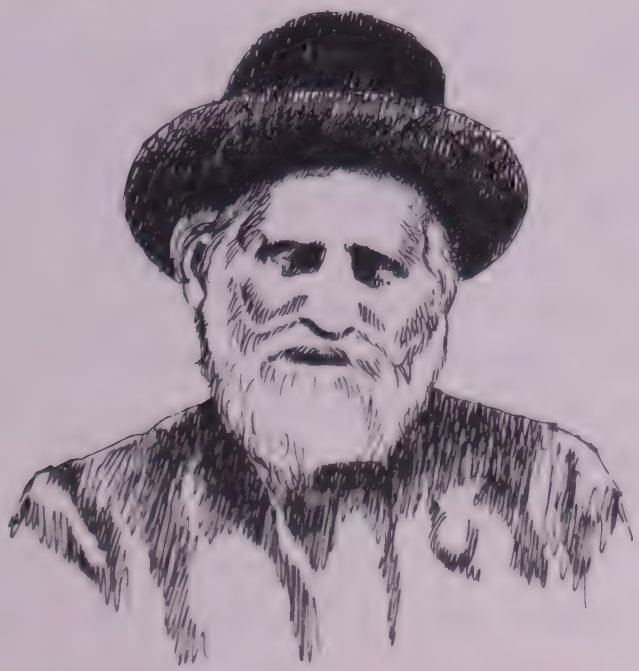
Pauli and Jung, who began their association in a very different way, went on to become good friends and collaborators. They presented their insights into what they

believed was a new principle of nature that would complement the approach of physics. They were both convinced of a greater symmetry that must exist, one in which events obey the greater principle of synchronicity. In one of his letters to Heisenberg, Pauli wrote: "Division and reduction of symmetry, this then is the kernel of the brute! The former is an ancient attribute of the devil...If only the two divine contenders—Christ and the devil—could notice that they have grown so much more symmetrical."

When Pauli died in 1958, Jung wrote of him: "It is most unfortunate that Pauli died so early, as he was a physicist who had the ear of his time, more so than a psychologist like myself..."

PAVLOV, IVAN PETROVICH
Physiologist (1849-1936)

This Russian physiologist won the 1904 Nobel Prize for his pioneering research on digestive glands and his work provided psychology with a more objective methodology and led to new methods of treating mental illness. Following his research on digestion in laboratory



animals, Pavlov provided a foundation for modern gastroenterology. He was able to explain the role of enzymes in digestion, and discovered the enzyme enterokinase. He also subsequently developed a theory of digestion that was of great value in the clinical pathology of the stomach and intestines. In 1901, Pavlov demonstrated his theory of 'conditioned reflex', in the famous experiment with dogs. In the 1920s, Pavlov extended his theory of animal behaviour to human psychology and the treatment of mental illness. His work provided psychology with a great boost, and laid the foundation for the behaviourist school of psychology which dominated Western psychological thinking until very recently.

Pavlov was an extraordinary researcher who invented entirely new techniques in his work in medicine and physiology. For example, in his study of digestion in animals, he had to devise a technique by which he could observe and study digestive processes over a long period of time. For this, he devised the incredible 'window in the stomach' technique, in which a permanent opening is made in the animal's abdominal wall to allow continuous observation of internal processes. In one case, he was actually able to observe digestive processes for as long as fourteen years!

Insufficient humidity once resulted in the loss of all of Pavlov's insects which were to be used in a series of experiments. When his wife chided him for failing to obtain a professorship that would have improved their otherwise modest financial situation, Pavlov retorted, "Leave me alone. A real tragedy has occurred. All my butterflies are dead, and you worry over a silly trifle!"

PLANCK, MAX
Physicist (1858-1947)

Planck was one of the greatest physicists from Germany whose research in thermodynamics and radiation led to

his discovery of the fundamental constant 'h', or the 'Planck's constant'. His quantum theory, which he announced in 1900, revolutionised the understanding of the subatomic world. Planck studied at the University of Berlin, under the legendary physicists Hermann von Helmholtz and Gustav Kirchhoff. After completing his Ph.D. on the second law of thermodynamics, he started teaching at Keil University, and subsequently became a successor to Kirchhoff at Berlin University. Planck's great contribution to physics was his formulation that energy exists in the form of packets called *quanta*, which laid much of the foundation for the science of quantum physics.

In late 19th century, there was a growing conviction among many that physics as a science had become complete, and that it required no further research. One such person was Planck's high school-teacher, who kept insisting every time he had the opportunity, to remind Planck, "Everything has already been done in physics. Better take up something else." Fortunately for science, Planck ignored his teacher's advice, and went on to obtain his doctorate at the age of twenty-one!

In spite of being one of the greatest physicists living in Germany at the time, Planck's later years were anything but happy. Unlike many of his counterparts who either supported Hitler in one way or the other, or ignored the growing Nazism, Planck openly resisted Hitler with firm courage and conviction. For this he and his family went through a great deal of anguish. The most cruel blow was when Planck's son Erwin was executed in 1945, on the accusation that he was plotting against Hitler. Planck never quite recovered from this tragedy and died a broken man, two years after the war ended, on 4 October 1947.

POINCARE, HENRI
Mathematician (1854-1912)

Poincare was the French mathematician and philosopher

of science, who is regarded as the greatest mathematician of his time. He graduated from the Ecole Polytechnique, standing first in his class. In 1879, he received a degree in mining engineering and a doctorate in mathematical sciences from the University of Paris. Poincare's work ranged over practically all the fields of pure and applied mathematics. He wrote more than 500 papers on new aspects of mathematics and more than thirty books on mathematical and theoretical physics and theoretical astronomy. His most famous popular work is his famous essay on the genesis of mathematical creation, which was published in 1908.

Such was Poincare's reputation as a genius that his mathematics professor at the university had nicknamed him 'monster of mathematics'. He had the distinction, according to what his contemporaries said of him, of knowing everything that there was to know of mathematics at the time. He was also an equally successful teacher, and he taught physical mechanics, mathematical physics, calculus of probabilities, celestial mechanics and philosophy of science.

Poincare always believed that science was essentially a study of aesthetics. He once said, "The scientist does not study nature because it is useful to do so. He studies it because he takes pleasure in it, and he takes pleasure in it because it is beautiful. If nature were not beautiful, it would not be worth knowing and life would not be worth living."

PORTER, JOHN ROGER
Microbiologist (1919-)

British microbiologist John Roger Porter had his book on microbial physiology published at the same time that his first child was born. A family friend, who heard of the latter event but had no idea whatsoever about the book, hastened to congratulate him and was astounded when

Porter, who was full of the book he had just got published, replied excitedly, "Thanks a lot. But I couldn't have done it without two of my graduate students!"

RAMAN, SIR CHANDRASEKHARA VENKATA
Physicist (1888-1970)

The Indian physicist, who was awarded in 1930 the Nobel Prize in physics for his work on the scattering of light, subsequently became popular as the man who discovered the 'Raman effect'. He also contributed to the physics of music and studied colour perception.

Raman graduated from the University of Madras and then chose to work for the Indian Department of Finance. At the same time his results of independent research on sounds made by various musical instruments were published. He accepted the chair of physics at the University of Calcutta in 1917, which is where he started his study of the scattering of light. He reported the results of his experiments, carried out with his associate K.S. Krishnan in 1928, for which he was given the Nobel Prize, just two years later. In 1933, Raman became Director of the Indian Institute of Science and stayed there for

the next fifteen years, before taking charge of the newly-founded Raman Research Institute, where he investigated crystal structure and colour perception.

Sir C.V. Raman used to make notes and remarks in every text-book he read, all his life. He had only three remarks to make: 'excellent', 'elementary' or 'silly'. He once remarked, "I feel very strongly about text-books. I think the only crime worse than reading one is to write one."

When he graduated, Raman's teachers urged him to go to England for further studies. But he was disqualified by the civil surgeon at Madras, who felt that Raman might not be able to withstand the rigours of the cold English climate. Years later, Raman is known to have said, "I shall be ever grateful to this man."

Raman was offered the Palit chair of physics by the then Vice-Chancellor of Calcutta University. However, India being a British colony at the time, one of the requirements for the appointment was training abroad. When Raman heard of this, he refused to go to England to be 'trained'. Faced with this, the Vice-Chancellor had no choice but to change the provisions for the endowment. Finally under pressure from Sir Asutosh, the then Vice-Chancellor, Raman did go abroad, but not to be trained. He went as a delegate to the Universities Congress at Oxford, and came into contact with some outstanding English scientists, notably J.J. Thomson, Ernest Rutherford and William Bragg. Raman loved to narrate the story of how moved he was when Rutherford recognised him sitting on a back bench at one of the lectures and invited him to come and sit next to him.

Few people know that the famous 'Raman effect' was arrived at with equipment worth Rs 200, and with extremely meagre facilities! "The essence of science," he once said, "is independent thinking and hard work, not equipment."

Raman was deeply interested in acoustics and did a

painstaking study of the harmonics of musical instruments. This got someone to quip that Raman was attempting to become a fellow of the Royal Society by fiddling around in physics!

Raman was known to be witty and would often intersperse his public lectures with jokes. On receiving a verbal intimation of the award that the Nobel Prize was to bring, he queried, "Am I alone or have I a bedfellow to share?" On another occasion, while he was in Europe, at a party, Raman the life-long teetotaller was offered a drink which he wittily declined with the remark, "You can see the Raman effect on alcohol, but not the effect of alcohol on Raman."

The state of Indian science and the bureaucratic tangles of independent India frustrated him endlessly. Upset with the hypocrisy of the new politicians, he once said, "These days all that you need for success in India is a Gandhi cap over your head and nothing under it."

Shortly before his death, he commented, "My life has been an utter failure. I thought I could try and build true science in this country, but all we have is a legion of camp-followers of the West."

RAMANUJAN, SRINIVASA
Mathematician (1887-1920)

This Indian mathematical genius got belated recognition as one of the greatest mathematicians ever. Had his life not been tragically cut short, Ramanujan's work would have undoubtedly been recognised within his lifetime as the work of a genius.

Born in a poor family in south India, Ramanujan received a scholarship to attend Government College in 1904, but his singular obsession with mathematics at the expense of other subjects, resulted in his being failed. However, he continued his mathematical investigation on his own and fortunately secured a job and started

publishing papers in the journal of the Indian Mathematical Society. In 1914, he was able to go to Trinity College, London. While at Cambridge, he published many papers on a variety of such topics as modular equations and approximations to pi; high composite numbers; definite integrals; and modular, elliptic, and hypergeometric functions. In 1918, Ramanujan was made a fellow of the Royal Society and of Trinity College. Due to bad health, he returned to India in 1919, where he continued his mathematical investigations.

A mathematics teacher, teaching in the eighth grade in a small school, was telling the class that any number when divided by the same number becomes unity. He was then left speechless when a thin, dark-eyed boy called Srinivasa suddenly interrupted and with a spark in his eye, asked, "Sir, is that true of zero, too?"

Though he failed his college examination, Ramanujan's facility in the theory of numbers was in a large measure intuitive. Many of the results apparently came to his mind without any effort. On one occasion, Mahalanobis went to Ramanujan's room to have lunch with him. Ramanujan was preparing something in a pan on the fire for their lunch. Mahalanobis went and sat near a table to glance

through the pages of the *Strand* magazine which, at that time, used to publish a number of puzzles to be solved by its readers. He suddenly got interested in a problem involving a relation between two numbers. Two British officers were billeted in Paris in two different houses on a long street, the number of these houses were related in a special way and the problem was to find out the two numbers. It was not a difficult problem and Mahalanobis got the solution in a few minutes by trial and error. He then jocularly told Ramanujan, "Now here is a problem for you."

Ramanujan said, "What problem, tell me," and went on preparing the food.

Mahalanobis read out the problem from the magazine and Ramanujan promptly answered, "Please take down the solutions," and dictated a continued fraction, the first term of which was the solution obtained by Mahalanobis and each successive term represented successive solutions for the same type of relation between the two numbers, just as the number of houses on the street would increase indefinitely. Mahalanobis was visibly amazed at Ramanujan's genius as a mathematician.

While conducting his mathematical searches, Ramanujan continued in his search for a job. After much effort and amidst growing poverty, Ramanujan finally found a job at the Madras Port Trust, where, in his spare time, he absorbed himself in mathematics and started publishing papers. He then started corresponding with the great British mathematician Godfrey Hardy of Cambridge University, who was impressed enough with Ramanujan's work to recognise his genius. He persuaded Ramanujan to enter Trinity College. What the two mathematicians—one, a British agnostic and a superb mathematician and the other, a simple Indian with mathematical powers that seemed to go beyond mere intellect—did together, is history.

When Ramanujan was in the process of looking for

a job, he had the overwhelmingly difficult task of finding some money for bread as well as paper for his calculations. He needed something like seventy large sheets of paper a day. When things became too difficult, he even started using scraps of paper that he found in public waste-bins and lying on the streets. Sometimes he even used a red pen to write over what had been written in blue ink on the piece of paper he picked up. And he would march into offices, showing them his frayed notebooks and sheafs of paper, trying to convince them that he could at least do a clerical job, but tragically no one ever understood what he was referring to in his notebooks.

Ramanujan spent his last days bedridden and sick. But the great mathematical brain was far from being inactive. When his mentor Hardy came over once to visit him at his bedside, he said, "I say, Srinivasa, I thought the number of the taxi I came in was a very dull one. It was 1729."

Without even a moment's hesitation, Ramanujan replied, "No, maybe not. It is not a dull number in the very least. It is the lowest number that can be expressed in two different ways as the sum of two cubes!"

Ramanujan frequently said that he dreamed of formulae, which he wrote down after waking up and then attempted to prove!

RAMON Y CAJAL SANTIAGO
Neuroanatomist (1852-1934)

Spanish neuroanatomist and neurohistologist, who shared the 1906 Nobel Prize for medicine with Camillo Calgi, for adopting and improving the silver-stain method for staining nerve tissue. Ramon Cajal received his Licentiate degree (roughly equivalent to a Ph.D.) from the University of Sargossa in 1873 and a doctorate in medicine in 1877. He then taught anatomy and medicine at

Barcelona and later at Madrid. With his improvement on Calgi's work, he laid the foundation of present-day knowledge of the structure of the nervous system. The exploration of the structure of the cerebrum was possible only with Ramon Cajal's silver-stain method. Using this technique, he went on to demonstrate, for the first time, the true relationship of nerve fibres with nerve cells. He established complete knowledge of the structure of the *neuron* (the word for a nerve cell) and the interconnection between neurons.

As a student, Ramon was erratic and rebellious, frequently playing truant and keeping company that his father, a country-barber, thoroughly disapproved of. Determined to discipline him and change his ways, his father apprenticed him to first, a barber and later, a cobbler. The hard and humble work paid off and Ramon went on to earn distinction as a doctor and a scientist!

RAMMELSBERG, CARL FRIEDRICH
Chemist (1813-1899)

This German chemist did pioneering work in physical chemistry at a time when other chemists had more or less seen the subject as fully developed. Rammelsberg is also renowned for his mastery of the chemical balance.

Rammelsberg spent the early years of his life in genteel poverty. But with characteristic energy, he started a private laboratory of his own in which all his early pupils must have obtained their experience. It was so small that only two students could be accommodated at a time, and when one pair went off, a second pair came in. The fee was ridiculously small, but with his meagre earnings, he managed to assist his mother to support herself.

Dr Liebert's recollections of Rammelsberg—the vision of a little man with his head thrust half into the balance case, rapidly changing weights with a quick, nervous action. He was never without a cigar in his mouth

and always encouraged his students to smoke in the laboratory!

Towards the end of his life, he was troubled by frequent, blinding headaches, but he was never idle. Lying on a couch in the library, he would call his wife from the next room and dictate the thoughts that entered his mind. His power of concentration enabled him to work undisturbed and the noisy presence of grandchildren was no hindrance at all.

RAMSAY, SIR WILLIAM
Chemist (1812-1916)

Ramsay was a Scottish chemist. He won the 1904 Nobel Prize in chemistry for his discovery and isolation of the inert gases of the atmosphere and placing them in the chemical periodic table. Ramsay received a doctorate from the University of Tubingen in 1872, and was appointed professor of chemistry at University College, London, where he remained till his retirement in 1912. Ramsay's early scientific work was with alkaloids and later, with the properties of liquids. Ramsay discovered the tiny presence of an unknown gas in the process of separating

nitrogen and oxygen from air. With Lord Rayleigh, who had begun the study of nitrogen, he announced the discovery and named the gas 'argon', which had been predicted in 1785 by Cavendish. Ramsay went on to discover three more previously unknown gases—neon, krypton and xenon—which formed a new group of 'rare gases' in the periodic table. In 1903, Ramsay and Soddy showed that heavy atoms can disintegrate into lighter ones and with Whytlaw Gray, in 1910, showed that a radium atom decayed into a radon atom by expelling a helium atom.

William Ramsay's other area of excellence was sports. It was said that had he not become a scientist, he would have gone on to become a great swimmer. "When we were in Paris," recalled a friend of Ramsay's once, "the four of us used to go for a bath in the Seine every forenoon. After the first time, when Ramsay was ready to dive from the high board, the bathman would pass the word around that the Englishman was about to take his dive. Everyone in the establishment, including the washerwoman outside, would then crowd around and take up position to watch him."

Sir Ramsay had a rare sense of humour that he used occasionally in his talks and writings. Once, writing of a certain trip he had been on, he said, "I went to Paris with three spirits more wicked than myself." Then he added, "Three lawyers. Three lawyers and a chemist; just like nitric acid, liable to explode at any moment."

RAY, PRAFULLA CHANDRA
Chemist (1855-1944)

This prominent Indian chemist was the most important member of a group of outstanding scientists in Calcutta, in the first two decades of this century. He was one of the forerunners of a movement to integrate ancient Hindu wisdom with Christianity and modern science. He is best remembered for his work, *The History of Hindu*

Chemistry, which was published in 1902.

From the small town of Jessore, Prafulla Ray moved to Calcutta with his family in 1870. His dream was to study at Presidency College, but his father who just about managed to make ends meet, could not afford the high fees and Roy instead went to Pandit Iswarchandra Vidyasagar's Institute. The dream of being in Presidency College, however, remained. He then went on to earn a scholarship for Edinburgh and on returning to India, was appointed lecturer at Presidency College in 1881. Eventually he became the head of the chemistry department.

While studying at Edinburgh for his graduation, Lord Rector announced a prize for the best essay on 'India before and after the Mutiny'. Ray submitted his piece after having done extensive research on the subject. Although the prize went to a British student, his essay found its way into a newspaper that referred to it as "extensive information that will not be found elsewhere."

Sir P.C. Ray was once invited to Lahore (now in Pakistan), to deliver a course of lectures on 'Hindu Chemistry', a subject which he had made his own. He had already published, through elaborate research, two large volumes on the subject. While he was addressing the vast audience, he noticed a young Englishman in the front row, who was obviously not happy with what was being said. Ray was talking about the great experimental skills of the ancient Indians, who had nothing but very primitive apparatus and yet carried out processes of chemical distillation in very crude earthen pots. While he was exhibiting this with the aid of diagrams, the Englishman could hardly suppress his sneers, making it very obvious what he thought of the whole thing. The old man kept noticing it, but carried on. He finished talking about the apparatus and then took in his hand a lump of *makaradhwaja*, which is re-sublimed mercuric sulphide, still prepared according to traditional Indian methods. In fact, Sir Purdy Lukis, the then Surgeon-General

of Bengal would often prescribe it to his patients as a stimulant. Sir P.C. Ray took the lump in his hands and said, "Look here, my friends, with such crude apparatus, the Indians, two thousands years ago, used to prepare such a fine chemical and used it to alleviate human suffering," after which he paused and looked at the young Englishman, and continued, "and this at a time when the ancestors of our friend there were eating raw berries and wearing raw hides!"

Sir P.C. Ray was once interviewing a young man who had been a lawyer for a few years, and now wanted to enrol himself for graduation in chemistry. Ray's first question was why he had left the court, to which he got a ready reply, "Sir, if I can have the M.A. degree, then I shall have the letters M.A.,B.L. suffixed to my name and my claims to a good clerical job will be stronger thereby."

Hearing this nonchalant reply, Ray lamented, "Oh, chemistry! To what purpose are you being diverted."

Sir P.C. Ray was at one time working on the phosphate of soda and superphosphate of lime, both of which had to be imported from abroad. Undeterred by the scant funds at his disposal, which made it impossible to import them, he decided to make them from cattle bones. He then proceeded to procure several bags of raw bones from the butcher and laid them out to dry atop the terrace of his house. Being the month of January, Ray expected fine weather and lots of sunshine. But as luck would have it, it began to pour soon after and rained incessantly for a fortnight! This resulted in the rotting of the flesh that was still attached to the bones, bringing maggots and swarms of worms. Flights of crows began to invade the terrace, scattering bits and pieces of the delicacies among the congested dwellings of his orthodox Hindu neighbours. Ray was implored to remove the nuisance and was told in no uncertain terms that the Corporation's health officer would be summoned if he failed to do so. Fortunately for him, a nitric acid distiller,

whose acquaintance Ray had made, came to his rescue. With his help, Ray carried away all the bones far away to a plot of land that had been rented by the distiller. The bones were then piled up and set ablaze at midnight. Suspecting foul play and thinking that a corpse was being disposed off, the local constabulary ran to the spot and apprehended the two men. To prove his innocence, Ray thrust a long pole into the bonfire and brought out clusters of loose bones. The policemen were finally convinced of the bonafide of the transaction and went their way!

Ray started preparing his own drugs, some of them were ayurvedic, and started exhibiting them at medical congresses. But many people then were averse to local products and considered them inferior to what could be imported from Europe. Indignant at the way Indian products were perceived, he established the Bengal Chemical & Pharmaceutical Works in 1892 that pioneered pharmaceutical research in India.

Ray's attitude to money was such that he gave away most of what he received, never wanting to keep any for himself. His lifestyle was so frugal that he only needed Rs 200 out of the Rs 1000 that he earned, and he gave away the rest for the propagation of chemistry, establishment of industries, betterment of industrial workers and for widows and orphans.

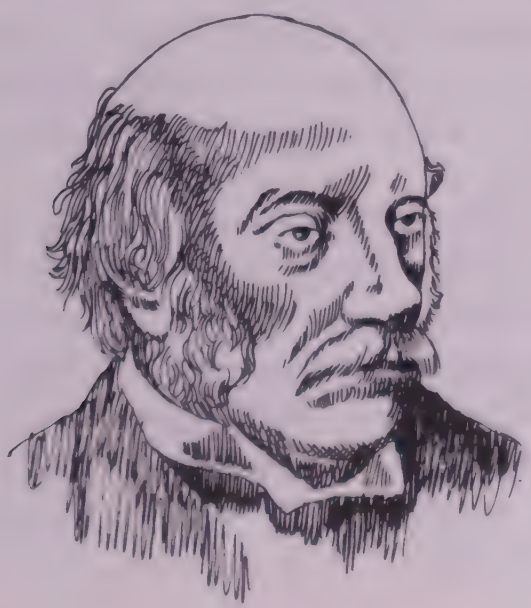
One thing about which Ray was uncompromisingly particular was his last meal of the day, which had to be at 9:30 p.m. sharp. If he was to take a train that started at that hour, he would arrange to carry all his food into the train and eat at the appointed time, rather than eat at home earlier. If he was visiting somebody's house, and if the meals were not forthcoming at that time, he would reach into his little bag and take out a little bread and sugar which he always kept with him, and then quietly retire to bed. No amount of persuasion on the part of the host would make Ray eat afterwards!

Always convinced that science in India needed to

stand on its own feet, Ray would often be critical about those who went abroad in search of 'better education'. In his autobiography, he wrote: "Professor Raman is practically self-taught and all his brilliant researches have been carried out in the laboratories of Calcutta...Ghosh and Saha did not care to have a D.Sc. (London) suffixed to their names for fear they would be lowering the doctorate of their own alma mater."

RAYLEIGH, LORD JOHN
Physicist (1842-1919)

The British physicist, who won the 1904 Nobel Prize for physics for his discovery of the argon gas, along with Sir Ramsay, received the prize for chemistry. Rayleigh graduated from Cambridge University in 1865, and set up a laboratory on his family estate. His early work was in the field of acoustics and optics, and he did pioneering work on resonance and an explanation of the blue colour of the sky as a result of the differing degrees of scattering of light. In 1879, he left his personal laboratory and became Cavendish professor of experimental physics at Cambridge. There he established standards of laboratory instruction and the redetermination of the electrical units



of the *ohm*, the *ampere* and the *volt*. Rayleigh returned to his private laboratory in 1884 and continued his research there.

One day, in September 1913, the British Association for the Advancement of Science was discussing the problem of radiation. In the august gathering were Marie Curie, Lorentz, Lord Rutherford and Lord Rayleigh. As the septugenerian Rayleigh was silent throughout the long discussions, Larmor needled him into getting to say something. Rayleigh quietly replied, "In my younger days, I took many views very strongly and one among them was that a man, who had passed his sixtieth year, ought not to express himself about modern ideas. Although I must confess that today I do not take this view quite so strongly, I keep it strongly enough not to take part in this discussion!"

ROENTGEN, WILHELM CONRAD
Physicist (1845-1923)

Roentgen was a German physicist to be awarded the first Nobel Prize for physics in 1901, for his discovery of X-rays and for ushering in a new era of medicine and modern physics. Roentgen graduated from the polytechnic in Zurich and after early work at the universities of Wurzburg and Strasbourg, became professor of physics at the University of Geissen, in Germany. In 1888, he became professor and Director of the Physical Institute at the University of Wurzburg.

It was in 1895, when Roentgen was experimenting with an evacuated glass tube (Crooke's tube) that he made his momentous discovery of an hitherto unknown radiation. This radiation seemed to pass through paper, wood, skin and other materials, and Roentgen called it X-ray radiation. Roentgen also worked on specific heat of gases, compressibility of liquids and gases and electrical phenomenon in crystals.

Roentgen may have discovered X-ray, but credit for it ushering in a new era of easy medical diagnosis must go to his wife. On 22 December 1895, after having waited long enough for Roentgen to come to supper, Mrs Roentgen walked into her husband's laboratory, and quite accidentally, placed her hands on a photographic plate that Roentgen was using in one of his experiments. And lo and behold, there was a strange looking 'photograph' of her hand. The rest is history...

RUTHERFORD, LORD ERNEST
Physicist (1871-1937)

The 1908 Nobel Prize for chemistry was awarded to this British physicist for working out the theory of the radioactive disintegration of elements. Rutherford was born and educated in New Zealand and pursued his higher studies at Trinity College, Cambridge University, where he worked under physicist J.J. Thomson. In 1898, Rutherford became professor of physics at McGill University in Canada, where he worked with British chemist Fredrick Soddy, on radioactive disintegration. Rutherford then distinguished the alpha and beta rays—which he named—and showed that radioactivity involved natural transmutation of radioactive elements. Later, he worked, with his assistants Hans Geiger and Ernest Marsden, on scattering of alpha particles by thin gold sheets. It was through this work that Rutherford demonstrated that an atom must consist of a small positively charged nucleus around which electrons circle. This became the basis for Niels Bohr's work on the atomic structure in 1913. In 1917, Rutherford was able to successfully bombard nitrogen with alpha particles, changing the atoms to oxygen atoms and thus becoming the first person to change one metal into another. Rutherford was appointed Director of the Cavendish laboratory in 1919, and raised to the peerage in 1931.

In 1895, when Cambridge University decided to confer degrees on graduate students from other universities, Ernest Rutherford was among the first few on the list. When his mother hurried into the garden to convey the good news to him, he was diligently digging potatoes. On hearing the news, he flung the spade aside and exclaimed, "These are the last potatoes I shall dig!"

When Rutherford was Director of Cavendish laboratory, he was nicknamed the 'crocodile'. According to Otto Hahn, there was some story about a crocodile that swallowed something indigestible that went on rumbling in its belly, so wherever it went, everyone would always hear it coming. Rutherford was called the crocodile because of his loud and emphatic way of talking that could be heard all the way down the corridor!

Rutherford loved to make good-humoured fun of students and researchers working under him. There was one student, a Scotsman named Russel, who Rutherford loved to joke with. He would often say to Russel that all Scotsmen were 'overscholarshipped' and 'overpraised'. One day at tea-time, he told Russel, "You, young fellows come down here from across the border with such testimonials written by your Scot professors that, why man alive, even if Faraday or Clark Maxwell were competing against you, they wouldn't get on the short list!"

Lord Rutherford was once standing in the drawing-room at Trinity when a clergyman came in. Rutherford looked up and announced, "I'm Lord Rutherford."

To which the clergyman replied, "I'm the Archbishop of York." According to Rutherford, neither of them believed the other.

A writer once remarked to Rutherford, "You are a lucky man, always on the crest of a wave!"

Came the laughing retort, "Well, I made the wave, didn't I?" and then a more sober, "At least to some extent."

When Rutherford was raised to peerage, a function

was organised to felicitate him. Niels Bohr attended the function and in a group discussion he referred to Rutherford as 'Lord Rutherford'. Rutherford was upset with this address and said to Niels Bohr later, "You lord me?" Rutherford was evidently upset by this address as he felt that it came in the way of their close friendship.

The close intimacy between the two scientists was further revealed when Lady Rutherford, after the death of her husband, sent to Niels Bohr the cigarette case used by Lord Rutherford and to which Niels Bohr reciprocated by writing: "This will remind me every day of his fatherly friendship."

SAHA, MEGHNAD
Physicist (1893-1959)

This Indian physicist came from extremely humble beginnings. His father was an impoverished grocer who wanted nothing more for his fifth child than to start earning for the family. But on advice of his local primary teachers, he reluctantly allowed the boy to attend a school, over fourteen kilometres away, with a well-wisher paying for the tuition fees. The young boy would walk that

distance every day, determined to finish his schooling. Later he began earning a little money by giving tuitions to children, cycling to distant places in the morning and evening to teach physics and mathematics. From these beginnings, the boy rose to be one of the greatest Indian scientists.

On numerous occasions Saha was misunderstood, possibly due to his calling a spade a spade and his intolerance of hypocrisy and pretence. A man who prefers plain-speaking and nothing but the truth seldom wins popularity. Saha, in this sense, was never the popular image of a scientist. During his time Saha was often accused of voicing dissent against the Hindu philosophy and the wisdom of the *Vedas*. It is a common enough mistake to suppose that a man well versed in modern scientific ideas would be ignorant of the classics or the scriptures. The fact that Saha was well read in the scriptures prompted him to declare in no uncertain terms: "The present writer claims that he has first-hand knowledge of all books (the Vedic literature)." The supreme confidence of tone and the aggressive style constituted the insignia of Saha, the fighter.

What was he fighting against? We have Saha's own account of it in one of his numerous popular and semi-scientific articles. After acquiring renown for his work on thermal ionisation, Saha went to Dacca. A lawyer of Dacca wanted to know the nature of his scientific work. With characteristic aplomb, the young Saha told him in great detail about the composition of stars and his latest findings. The listener, however, seemed unimpressed. Every other minute he interrupted to comment, "But this is nothing new, we have all this in the *Vedas*."

Disgusted, Saha asked him, "Would you be kind enough to tell me exactly in which part of the *Vedas* do we find the theory of ionisation of stars?"

Much to Saha's dismay the undaunted gentleman replied, "Well, I haven't read the *Vedas* myself, but it is

my firm conviction that whatever you people claim as a new scientific discovery is all contained in the *Vedas*."

Saha spent the next twenty years of his life in studying the *Vedas*, the *Upanishads*, the *Puranas* and all the Hindu astronomical texts.

Perhaps Saha could have stayed away from politics and still be of service to the nation had the events taken the course he so desired. He felt that the river projects were not being managed properly and that there was a general confusion in planning. It was no longer possible to limit his protests to the fiery editorials of *Science & Culture*. The only way to voice his protest and be heard was from the floor of the Parliament. That was the only way to inform the public and make the government rectify the mistakes. Saha stood for the first Constituent Assembly elections and won, to join politics.

SAHNI, BIRBAL
Palaeobotanist (1891-1949)

In 1932, Birbal Sahni was visited by a foreign scientist who had come to Lucknow to meet the great palaeobotanist of India. The foreigner was amazed to find Sahni sitting in a corner of a small botany museum. "You don't have a room to yourself!" he exclaimed.

"Great scientists have worked in garrets. I am only an amateur," was the smiling reply.

SALK, JONAS EDWARD
Epidemiologist (1914-)

This American medical research scientist developed the first vaccine against poliomyelitis. Salk took his medical degree from New York University College of Medicine in 1939, and in 1947 became head of the University of Pittsburgh's Virus Research laboratory and taught preventive medicine. From 1942 to 1947, Salk also worked

for the US Army on the development of a vaccine against influenza. In 1949, John Enders and his microbiology group at Harvard found a way of culturing polio virus for study. By 1952, Salk and his group had prepared and successfully tested such a vaccine. In 1963, Salk became Director of the Salk Institute for Biological Studies at San Diego in California.

The search for a polio vaccine was on and the two groups that seemed nearest to the final discovery were Enders' group at Harvard and Salk's group at Pittsburgh. After Enders had succeeded in culturing the virus, Jonas Salk began his attempts at combating the virus with a vaccine in a way that it was incapable of causing disease, but capable of producing antibodies. He finally succeeded in preparing such a vaccine, thus creating medical history. When the reporters came, Salk was sitting in his laboratory, engrossed in his work. "How did you arrive at the vaccine?" asked one of the reporters.

"Well," replied Salk with characteristic humility, "Enders threw a long forward pass and I just happened to be there to catch it."

Salk was interviewed by Edward R. Murrow who asked, "Who owns the patent right of the vaccine?"

Salk replied, "It will be the people I would say. There is no patent. Can you patent the sun?"

His biography written by Jane S. Smith carries the title *Patenting the Sun*.

SHALER, NATHANIEL
Geologist (1841-1906)

This well-known American geologist did more than anyone else in his field to popularise geology as a subject in the last century. Much has been recorded about Shaler's ecclectic teaching style and his impact on students at Harvard, where he taught for most of his life.

Student legend at Harvard has it that Shaler's method

of grading consisted of piling up all the examination notebooks in a mountainous heap on the sofa. After they had aged a week, he would plunge both hands deep into the uncorrected papers and carry all he could hold to a chair on the opposite side of the room. A second week would go by and he would carry another armload to another chair; and on to the third and fourth week until all books had been transferred from their original resting place on the sofa. Those in the first chair, he gave A's; those in the second got B's; the third, C's; the fourth, D's, and all those that had slipped off onto the floor in this impartial evaluation system, were considered flunked!

SCHEELE, CARL WILHELM
Chemist (1742-1786)

The Swedish chemist, who discovereed more new chemical substances in his lifetime than anyone else, was born in Stralsund, which is now in Germany. He worked as a pharmacist in Malmo, Stockholm and Uppsala., and after 1775, in Koping. Early in his career, he isolated tartaric acid, and in his later years, isolated gallic acid, malic acid, citric acid and oxalic acid.

Among the inorganic compounds, he was the first to isolate the toxic gases—hydrogen sulphide, hydrogen fluoride and hydrogen cyanide. Scheele also discovered the coloured compound, copper arsenite, which came to be known a Scheele's green. He was also the first to demonstrate the presence of calcium phosphate in bone. In his honour, the mineral from which he first obtained tungstic acid, in 1781, is still called *scheelite*.

Scheele is probably one of the most unfortunate scientists ever. He either discovered or greatly contributed to the discovery of manganese, nitrogen, oxygen, tungsten, barium, molybdenum and chlorine. But incredibly enough, in each of these cases, the credit went to someone else. In the case of chlorine, for example, he actually

isolated and described it in 1774, but did not give it the status of a separate element. And so, the credit went to Humphrey Davy twenty-six years later! Worse still, Scheele discovered oxygen as early as 1771, but owing to a grossly negligent publisher, the description of his experiments was delayed until it was too late; for Joseph Priestley published his discovery three years later, and got the credit for it!

When Gustav III of Sweden was in Paris, a deputation of French scientists called on him. They congratulated him on the achievement of his fellow-countryman and subject Scheele, the great discoverer of chemical substances. The King, who took little interest in the progress of science, felt somewhat ashamed that he should be so ignorant as never even to have heard of the renowned chemist. He dispatched a courier at once with the order, "Scheele is to be immediately raised to the the dignity of a Count."

"His Majesty must be obeyed, but who the hell is Scheele?" said the minister.

And a secretary was sent off to make inquiries. He returned with the details. "Scheele is a good sort of fellow," he said, "a lieutenant in the artillery, a capital shot, and a first-rate hand at billiards."

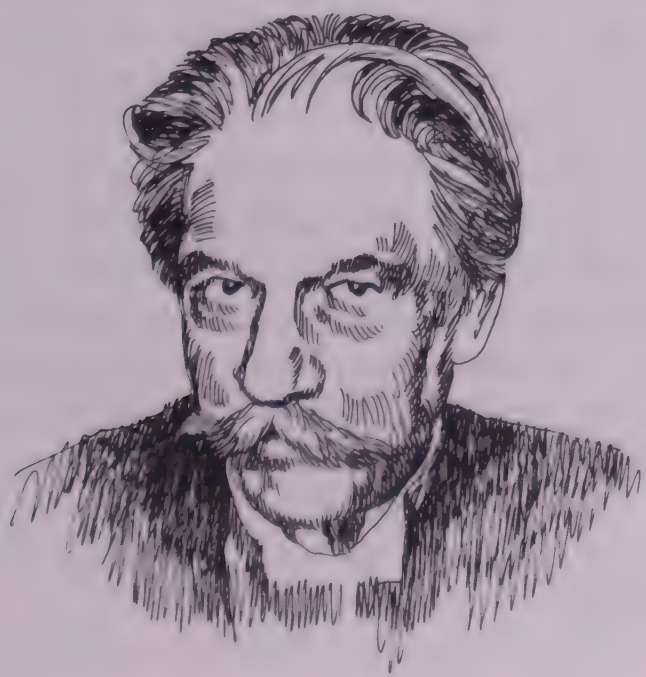
The next day the lieutenant was summoned to the court and made a Count. And the chemist was forgotten by the King and court!

As one of the greatest chemists of his time, whatever chemistry Scheele had learnt was 'hands on'; he never went to any college or university, but instead became an apprentice in an apothecary in Gotheborg in Sweden. He remained a pharmacist for the rest of his life. Before he died at the age of forty-three, in the last years of his life, Scheele suffered from severe attacks of rheumatism. He never married until three days before his death, and that was only so that his wife may inherit his pharmacy. She happened to be the widow of the former

owner of the pharmacy from whom Scheele had bought it twenty years ago!

SCHWEITZER, ALBERT
Scholar (1875-1965)

French-German scholar, humanitarian and spiritualist Dr Schweitzer became famous in music, theology, philosophy and medicine, and as a charismatic spiritual leader. Schweitzer received doctorate in philosophy in 1899, with a thesis on Kant from the University of Strasbourg. He became one of the great church and concert organists of his time and he himself designed and built some of the world's well-known organs. As a religious thinker, he wrote *The Quest of the Historical Jesus*, in 1906, which became one of the most widely read books of that time in the field of theology. In 1905, Schweitzer went to the Congo as a medical missionary, where he and his wife founded the Schweitzer Hospital in Lambarene, Gabon. Schweitzer spent the rest of his life in Africa and died in 1965 at Lambarene. In recognition of his accomplishments, he was awarded the 1952 Nobel Peace Prize.



Schweitzer had a phenomenal influence on people wherever he went. Wherever Schweitzer's story was known, people were affected and their lives changed. For instance, Larimer Mellon, a member of one of the wealthiest families in the United States, was so deeply moved by Schweitzer's selfless dedication that he returned to college in his forties, took a medical degree and with his wife, founded the Albert Schweitzer Hospital in Haiti.

As a young student, Albert Schweitzer had resolved that after he became thirty, he would devote all his energies to helping people. And so, on his thirtieth birthday, to the dismay of his friends and colleagues, he enrolled for intensive studies at the university's medical school in order to equip himself for service as a medical missionary. He was able to pay for the medical school expenses from the sale and royalty of his book on Bach, and from whatever he had earned from his concerts.

In 1912, he married Helene Bresslau, who had studied nursing in preparation for the missionary work. In 1913, Schweitzer obtained his medical degree and with his wife, went to Africa. There they founded their hospital at the edge of the Ogooue River, where during subsequent decades, many thousands of Africans received life-saving treatment.

During Schweitzer's visit to America in 1949, a former school pupil met him at the railway station and took him to a restaurant for breakfast. A cake that was specially made for the occasion was produced, giving the table a festive look. Dr Schweitzer was handed the knife and asked to cut the cake. He stood up and counted the number of people. There were nine of them, but he cut the cake into ten pieces. "One piece for the young lady who has so graciously served us," he said, handing the tenth piece to the waitress.

SEMMELWEIS, IGNAZ PHILIPP
Physician (1818-1865)

This Hungarian physician is credited with being one of the best medical instructors in Europe. His ideas on surgery were however considered to be too esoteric for his time and much of his medical career was spent in defending himself against charges made by his contemporaries.

In 1846, Ignaz Semmelweis was appointed to the Obstetrics Clinic at a rather prominent hospital in Vienna. Taking over duties the next day, he ordered his medical students to wash their hands in chloride of lime, before attending to the patients. Some of the students went and reported this unusual request to the Dean, who, not understanding the importance of cleanliness in medical practice, was convinced of the mental instability of Semmelweis. On his orders, Semmelweis was arrested and confined to the local mental asylum as a patient!

SIEBOLD VON CARL THEODOR ERNST
Zoologist (1804-1885)

This German zoologist was reputed to be a gifted scientist who sometimes used some unusual techniques to produce scientific results. He discovered, among other things, the source of tapeworms in human intestines.

Siebold and his fellow-workers were convinced that certain bladderworms were responsible for the occurrence of tapeworms in humans. But before being absolutely certain and making their results public, a crucial experiment was necessary to establish the hypothesis. Characteristic of the man, Siebold did not see any difficulty whatsoever in this. Not only did he swallow the bladderworms, he made his assistants do the same, and in due time the whole group became infested with tapeworms, thereby proving the hypothesis!

SIMPSON, SIR JAMES YOUNG
Obstetrician (1811-1870)

This Scotsman, who pioneered the use of chloroform and first used it as an obstetric device in reducing labour pains, acquired his reputation due to the antagonism of the clergy, and his clever attempts to resolve the tangles he found himself in.

The person on whom Dr James Simpson first used chloroform was a fellow-physician's wife. The interesting thing was that neither the patient nor her husband had been informed by Simpson about this. The baby grew into a charming little toddler and Simpson asked for a copy of her photograph. He captioned it 'Saint Anaesthesia' and placed it on his table, where it stayed till the end of his life.

After it became known that Simpson was using ether and chloroform in midwifery practice, there was a storm of protest from the clergy. They held that it was unnatural and sinful to allay the pain of childbirth since the *Curse of Eve* reads, "In sorrow thou shalt bring forth children."

Refusing to be taken in, Simpson argued that original scriptures had been wrongly translated and that the true meaning of the Hebrew word was 'effort', and not 'sorrow'. His quick-wittedness won the battle for Simpson; he had not the faintest idea about what was in the scriptures and had made this up on the spur of the moment!

STEINMETZ, CHARLES 'PROTEUS'
Electrical engineer (1865-1923)

This German-American pioneered the development of modern power systems using alternating current. A student of the University of Breslau, he had to flee Germany in 1888 to Zurich and then to the United States, where he stayed for the rest of his life.

Steinmetz's first important research was on the phe-

nomenon of *hysteresis* by which power is lost because of magnetic resistance. This research led him to a study of alternating current and motors could be made more efficient. Since there was no available theory of alternating current, Steinmetz set to work on formulating such a theory and worked on it for the next twenty years. In 1893, Steinmetz joined the newly organised General Electric Company in Schenectady, serving as consulting engineer until his death in 1923. He wrote a number of books, including *Engineering Mathematics* (1910) and *America and the New Epoch* (1916).

As a student at the University of Breslau, Steinmetz, in spite of his handicap of being a hunchback, was actively involved in student politics and was a committed socialist. He even began and edited a weekly called *The People's Voice*, which soon ran into fianancial trouble. One day the printer and the paper merchant arrived to demand immediate payment of a long-standing bill. Unfazed by the seriousness of the demand, Steinmetz led the gentlemen into the rear office and in a hushed voice said, "May I offer you a complete file of our back issues? Quite unobtainable elsewhere."

In 1888, Steinmetz wrote a particularly outspoken editorial criticising the government in no uncertain terms. Tipped off that he was soon to be arrested, he rounded up all his colleagues and took them to a pub and bought them all a round of beer. After much singing and merry-making, Steinmetz proposed a final toast: "To my father whose greatest desire it had been to see me graduate with honours. To my escape over the Swiss border from the police who are planning to arrest me as a socialist. To my senior thesis that might have come to a glorious end in publication rather than in a hideaway suitcase. To the world and its irony."

It was dawn when he tiptoed into his father's room. The older man stirred a little in his sleep and said in a half-sleepy voice, "I have had such a pleasant dream,

Karl...your future."

"Yes, Father, my future...it was a pleasant dream, was it not?" It was Karl's last meeting with his father. A few hours later he left Germany forever and became Charles Steinmetz.

STEPHENSON, GEORGE
Inventor (1781-1848)

This British inventor was the founder of railways. Stephenson was born into abject poverty and began his career as a poor watch-repairer. In 1815, he designed and produced his version of the miner's safety lamp, while Davy was still carrying out his experiments. When Davy's lamp appeared, there was violent controversy as to who should receive credit for the invention.

Once, pointing to a running train, Stephenson asked the geologist Beckland, "I say, Beckland, what do you think makes that train go?"

"Why," replied Beckland, "the hand of the driver of one of your wonderful locomotives."

"No," replied Stephenson.

"Well, then," said Beckland again, "the steam that moves the machine?"

"No."

"The fire kindled under the boiler?"

"Wrong again," replied Stephenson and continued. "It is activated by the sun which shone in that far-off epoch when the plants were alive that afterwards changed into the coal that the driver is shovelling with the stoker."

TESLA, NIKOLA
Inventor (1856-1943)

This Croatian-American inventor did pioneering work on the radio and invented the alternating current motor system that made it possible to transmit and distribute electricity.

Tesla studied at the University of Prague in 1881, before he began work for the newly founded telephone company in Budapest. In 1882, he moved to the Continental Edison Company in Paris. Tesla went to the USA in 1884, where for nearly a year, he redesigned for Thomas Edison in New York city. He established his own laboratory in 1887 and began his phenomenal research career. His first and greatest achievement was his discovery of the rotating magnetic field, which provided the first practical means of generating large quantities of electricity and transmitting it over long distances. It became possible to harness the Niagara Falls for electricity and thus began a new era of street lighting.

Tesla's other great invention was the Tesla coil for generating high frequency currents, which made pioneer contributions to the then unborn fields of high frequency induction heating, diathermy and radio.

Tesla received innumerable honours during his lifetime. In 1956, as part of international commemorations of his birth centennary, the term *Tesla* (T) was adopted as the unit of magnetic flux density.

Tesla, the electrical genius, was without a job upon

arrival in New York city. Pride prevented him from appealing to his relatives for help. In the street, he saw a long line of men, and when he asked what it was for, he got the reply, "Jobs."

"What kind?" asked Tesla.

"They're gonna dig a ditch from here to clear up into the open country past Forty-Second Street. Gonna lay some conduit for electrical cables or something. They advertised for husky men."

"What's the pay?" asked Tesla.

"Two dollars a day," was the answer.

"I guess I am husky enough." So saying, Tesla stepped into the line.

Tesla was also a brilliant mathematician, constantly looking for problems to solve. In a restaurant, he would not touch his soup until he had first calculated the amount of liquid in the bowl. One night, the waiter brought him a bowl of fruit salad. Each piece was of a different size and shape. Tesla's eyes lit up. Fifteen minutes later, his pencil was still flying over his pad, covering it with mathematical symbols. The waiter approached him, "Is there something wrong with the fruit salad, sir? You haven't touched it at all."

"Wrong? Of course not," replied Tesla, without looking up. "It couldn't be better."

THALES

Philosopher-scientist (640 B.C.-546 B.C.)

The first known Greek philosopher and scientist Thales is traditionally regarded as the father of philosophy and was the first of the seven sages of Greece. He is also acknowledged as the inventor of theoretical geometry and abstract astronomy. In mathematics, Thales first demonstrated that a circle is bisected by its diameter, that the angles at the base of an isosceles triangle are equal, that two intersecting straight lines produce

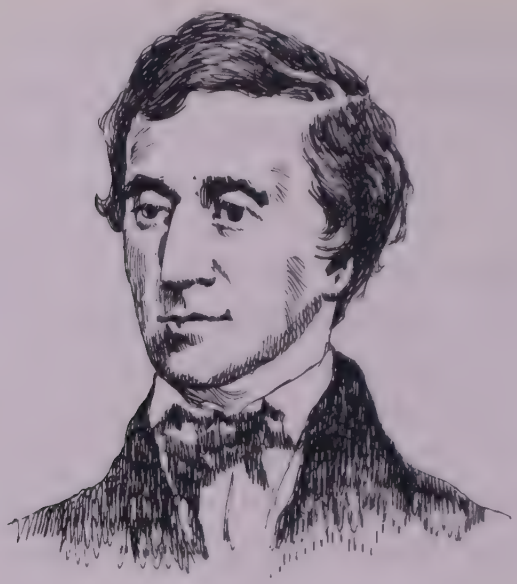
opposite and equal angles and that the angle of a semicircle is a right angle. In astronomy, Thales was the first to determine the sun's course from solstice to solstice, and to estimate the size of the sun and the moon in relation to their cycles. Thales was also the founder of the Ionian School of Philosophy, which was chiefly concerned with the physical world and taught that water is the universal primary substance.

Thales commanded great respect during his lifetime in Greece, and some even thought that he had learnt some magical powers when he was studying in Egypt as a young boy. The reason for the awe about Thales is understandable—he accurately predicted, a year before the event, the total eclipse of the sun on 28 May 585 B.C.!

Once on a nocturnal walk in the street, Thales was so engrossed in contemplating the stars that he fell into a ditch and badly injured his knee. He was pulled out by an old woman who rebuked him that he must have been a liar to have claimed knowledge of heavenly bodies, when he could not even see what lay at his feet.

THOREAU, HENRY DAVID
Naturalist (1817-1864)

This American naturalist, literary artist and member of the transcendentalist group that flourished in 19th century New England, USA was deeply influenced by Ralph Waldo Emerson's essay, *Nature*, with whom he developed a lasting friendship. Born in Concord, and educated at Harvard, Thoreau taught at school and occasionally helped his father in his business. In 1845, he revolted against the government and in jail, wrote his best-known essay on 'Civil Disobedience'. Thoreau wrote prolifically although he could never earn a living by writing as the audience for his kind of writing was especially limited. He is best remembered for his *Walden* and *A*



week on the Concord and Merrimack Rivers and *Journal.*

Ralph Waldo Emerson remained the greatest influence on Thoreau all his life. Once when asked, what had his college career at Harvard given him, Thoreau replied, "The discovery of the world of books and Ralph Waldo Emerson."

From 4 July 1845 to 6 September 1847, Thoreau carried out his legendary experiment in living at Walden Pond, in an attempt to find out whether he could support himself in a minimal way by light manual labour and thus have most of the time free for writing. When he left the pond, he had completed the manuscript of *A Week on the Concord and Merrimack Rivers* and an early draft of *Walden.* Thereafter, he lived at his family's home in Concord and made a bare living as a handyman, so that he could have time for writing and for nature rambles.

Thoreau was such an enthusiastic naturalist that Clifton Fadiman used to say of him that he could get more out of twenty minutes with a chickadoe than most men would from a night with Cleopatra!

It was the general opinion of most of Concord's citizens that Thoreau was an eccentric. His life was marked by whimsical acts and unconventional stands on public

issues. When he expressed his deepest convictions through dramatic action, he was often misunderstood by many. His most famous act of defiance was against the Mexican war and the extension of slavery, by his refusal in 1845 to pay his taxes. For this he was put into jail, where he wrote his classic essay 'Resistance to Civil Government', which was later called 'Civil Disobedience', and which became an inspiration for the American Civil Disobedience Movement in the 20th century.

The story goes that when Thoreau was on his deathbed, a pious aunt who visited him inquired earnestly, "Henry, have you made your peace with God?"

To which he replied, "I did not know that we had ever quarrelled!"

TYNDALL, JOHN
Physicist (1820-1893)

This Irish physicist is best known for his work on the transparency of gases, the absorption by gases and liquids of radiant heat, the qualities of atmospheric light and the sterilisation of air and liquids. He discovered the so-called Tyndall effect, in which the blue colour of the sky is imitated. Tyndall received his Ph.D. at the University of Marburg and later at Berlin. He was appointed professor of physics at the Royal Institution, London in 1854, where he worked with Michael Faraday. Tyndall also studied glaciers and meteorological conditions in Switzerland.

In 1853, when it became known in the Royal Society that the year's two gold medal awards were to go to Charles Darwin for biology and to Tyndall for physics, many of the Society members launched a campaign against Tyndall. They felt that his work was not original as it was based on that of physicists with whom he had worked in Germany. The hapless physicist, who was disgusted with the narrow views of his colleagues, sought the

advice of his mentor Michael Faraday, and accordingly wrote to the president of the Society that he would not accept the award.

VESALIUS, ANDREAS
Physician (1514-1564)

Dr Vesalius was a Flemish anatomist and physician and is best known for his great work, *De human corporis fabrica*, which was published in 1543.

Born into a family long associated with the medical care of the imperial dynasty, Vesalius received the doctor of medicine degree from the University of Padua, and he soon joined the faculty to teach surgery and anatomy. It was while he was at Padua that he composed the *Fabrica*, which remained influential for two centuries and because of its typographical excellence and remarkable woodcut illustrations, was one of the finest examples of 16th century bookmaking. Vesalius moved to Spain in 1559 and died on a ship voyage in 1564.

Sitting high above the dissection table and at a safe distance from the evil-smelling cadaver, the professor of surgery at Padua was imperiously directing his students

to dissect and expose the anatomical parts. The students kept hacking away until Andreas Vesalius, a young Flemish student, could take no more, and elbowed his way forward, pushing the others aside. To the amazement of all, he proceeded to separate and expose each organ and tissue with a delicate precision and skill never seen before. The professor, Jocobus Sylvius, however was furious and he remained Vesalius' enemy till the end.

Vesalius's surgical skills were legendary. He dissected every sort of animal he could find, to increase his skill of mammalian anatomical structures. After public executions, he would creep out in the dark of the night to exhume corpses for his study. On one such nocturnal excursion, Vesalius saw an almost intact skeleton swaying from its chains, high up in the gallows. Scavenger birds had consumed every bit of the deceased criminal's body, down to the clean white bones. Vesalius carefully wired the bones together in their natural positions and had his first complete skeleton. He eventually knew every protuberance and depression of every bone in the skeleton in a way no anatomist had ever done. And it stood like a close friend at one end of his laboratory table, overlooking every dissection he performed during the subsequent years.

Sylvius had condemned his former student as a "madman whose pestilential teachings were poisoning Europe". Vesalius was shocked to know that he was discredited even by his other colleagues and students at the university. In disgust, he left Padua, never to return. Vesalius was only thirty then but his career as a scientist had ended. He accepted an invitation to the Spanish court in 1559, where he became physician at the court of Philip II.

The heavy hand of the Spanish Inquisition hindered any advancement in the natural sciences and the dissection of the human body was considered a sacrilege. Wrote Vesalius: "I could not even lay my hand upon a dried

skull, much less take the chance of making a dissection."

Eighteen years later, after his old enemy Sylvius had died, Vesalius was invited back to Padua to take the chair of anatomy. Savouring his moment of celebration, Vesalius decided to make a pilgrimage to Jerusalem before returning to Padua. On the return journey, he was ship-wrecked during a violent storm, and died on a small island off the Greek coast, where he was buried.

WATERTON, CHARLES
Naturalist (1782-1865)

This British naturalist achieved fame for his collection of species and for popularising the science of zoology among the lay people. His eccentric behaviour, however, made him a laughing stock and much of his later life was spent as a recluse.

Legend has it that Waterton's love for animals went to extraordinary lengths. For most of his life, he went to bed accompanied by a huge boa constrictor, a little more than four metres long, after he had kissed a tender goodnight to a chimpanzee!

WELLS, HERBERT GEORGE
Novelist (1866-1946)

Wells was the British novelist and writer of science fiction. Born in Kent, England and in spite of an unfinished education, Wells went on to become one of the greatest science fiction writers ever and a respected social commentator.

Wells's father was a shopkeeper and a professional cricketer, and his mother, a housekeeper at a nearby estate. He started writing in 1891, with an article called 'The Rediscovery of the Unique' which was published in *The Fortnightly Review*. *The Time Machine*, a science-fiction novel of prophetic quality, came in 1895. That was followed by

six other works between 1896 and 1901, that established Wells as a writer of repute; and these included *The Island of Dr Moreau* (1896); *The Invisible Man* (1897); *The War of the Worlds* (1898); *The First Men in the Moon* (1901). His later novels reflected his hostility to the Victorian social order and its orthodoxy and his novels became all the more prophetic with *Anticipations* (1903); *Mankind in the Making* (1903); *A Modern Utopia* (1905). Wells' last book of enduring value was his *Experiment in Autobiography* (1934).

George Wells attended Morle's school in Bromley for his real education which became a habit when he was laid up in bed with a broken leg—omnivorous reading. Between 1880 and 1883, he was forced to spend most of his time as a draper's apprentice in South Sea. He detested this experience so badly that he made this the theme of his novel, *Kipps*, which he wrote almost twenty years later!

For some time, one of Wells'closest friends was George Bernard Shaw, who claimed that he and Wells, between them had 'changed the mind of Europe'. Both were members of the famed Fabian Society, which Wells tried to turn into a large-scale operation devoted to social and political action. As a result of his views, he and Shaw consequently fell out and he resigned from the Society in 1908. He described his whole bitter experience with the Fabian Society in *The New Machiavelli*, in 1911.

The special conference on 'Science and the World Order', held by the British Association for the Advancement of Science in September 1941, took an unexpected turn. H.G. Wells, the great populariser of science and not always a favourite with scientists, was delivering his lecture. Much before he had finished, he was asked by the chair to cut short his address as he had overstepped his time. Wells took this as a slight, but soon got his own back. The next speaker happened to be Sir Lancelot Hogben, who had been in the chair the earlier day and the chairperson, none other than Wells. Hogben started speaking

and halfway through the speech, quite unexpectedly, he was grabbed by the somewhat expansive seat of his trousers and pulled down to his chair. Poor Hogben's address came to an abrupt and rather undignified halt. And Wells had the look that comes from a job done well.

WISLICENUS, JOHANNES
Chemist (1835-1902)

This German chemist did pioneer research on isomers. Wislicenus was educated at Harvard and then at Zurich University, where he subsequently became professor of chemistry. He is also known for his work on acetoacetic ester and its application as a synthetical agent and for his synthesis in the pentamethylene series.

Shortly after the conclusion of peace between France and Germany, a gathering of the German inhabitants of Zurich decided to celebrate the occasion and Wislicenus was nominated the chairperson. Soon after the function started, some from the public forced their way in and started attacking the audience with stones and set fire to the staircase. In the ensuing panic, the scientist took charge and appealed to the vandals to stop. He then proceeded to, with utmost coolness, demonstrate to the audience how fire could be extinguished most effectively with beer!

Wislicenus always gathered his students around him at his simple mid-day meal. The warm feelings entertained towards him by the students gave him keen pleasure, but he disliked any formal tokens. When he found out, quite by accident, that preparations were afoot to commemorate his approaching sixtieth birthday, he showed his distress in the plainest possible fashion such that his well-wishers had no alternative but to abandon the idea of a formal celebration.

Appendix-I

Outline of Science

The environment of man consists of different spheres: astrosphere, atmosphere, lithosphere, hydrosphere, biosphere and psychosphere. These spheres are not isolated and sealed from one another, but are inter-permeative and interactive. The happenings in one profoundly affect action in the rest. In each sphere there are certain facts and phenomena *firstly*, for observation and for explanation, and *secondly*, for control and exploitation. Man meets these environmental challenges intellectually by postulating *theories* to *explain* and *understand* these facts and phenomena and then, through their understanding bring about technological advances for the benefit of mankind.

Astrosphere

The theory of solar system
The theory of origin of our planet

Atmosphere, Lithosphere and Hydrosphere

The theory of the structure of earth
The theory of the structure of matter
The law of the periodicity of properties of elements
The theory of the tetrahedral carbon atom
The theory of radioactivity
The theory of heat
The theory of light
The theory of electromagnetic waves
The theory of relativity

Biosphere

The theory of cell
The theory of carbohydrate synthesis in plant life
The theory of evolution
The theory of circulation of blood

The theory of disease
The theory of immunity
The theory of heredity

Psychosphere

The theory of mind.

Appendix-II

Fields of Scientific Knowledge

No.	*Environment*	*Action*	*Science*	*Practical Achievement*
1. Astrosphere	The sun, moon, the planets, the star, interstellar space.	Earth's rotation round its axis and revolution round the sun; rays from the sun, effect of the sun and the moon on the earth (tidal effect).	Astronomy Physics Chemistry	Observatories (telescope, spectroscope, radio) and unmanned/manned satellites.
2. Atmosphere	Different layers and belts.	Climate and season zones—arctic, temperate, and tropical.	Meteorology Aeronautics Physics Chemistry	Weather forecast, air-navigation, air-conditioning.
3. Lithosphere	Mountains, valleys, plains, deserts.	Mining, farming.	Geology Metallurgy Chemistry	Discovery of mineral deposits, petrol, agricultural instruments, dyes, fertilisers, and synthetic products.
4. Hydropshere	Sea, river, rain, wells.	Navigation, irrigation, industrial and potable water.	Chemistry Physics	Steam engine, hydraulic power, ships, dams, drainage.
5. Biosphere	Living beings—macro and micro (animals, bacteria), vegetables, flowers, cereals.	Food, domestication, health and disease.	Botany Zoology Bacteriology	Cultivation of fruits, vegetables, antibiotics and antioptics.
6. Psychosphere	Individuals Classes Nations Races.	Personality, habits, customs.	Ethnology Anthropology Sociology Psychology	Community of nations, psychotherapy.

Appendix-III

Science, Scientist and Truth

To determine the status of truth in science it is necessary to define the term 'truth' first. Truth is a multi-ordinal term which acquires a different meaning in a different context. There could broadly be three kinds of truths—historical, artistic, and scientific. In all these three fields of cognitive approaches, we can consider the imagination as a springboard to reach the ultimate. When the imagination works on documentation, we get the historical truth; when the imagination works on experience, we get the artistic truth; and when the imagination works on experiment and observation, scientific truth is achieved. Scientific truth is provisional while the artistic truth is perennial. Tennyson in his *Vision of Sin* has said:

Every moment dies a man,
Every moment one is born.

A statistically-oriented scientist may detect a falsehood in the above couplet in view of the population explosion and correct it to read as follows:

Every moment dies a man,
And one-and-sixteen is born.

Tennyson's eternal truth talks of a flux of life while in the second case we see a provisional truth changing on the basis of the demographic graph.

Dr Peter Medawer, Nobel laureate, has said that the goal of the scientific world may be better represented as an asymptote, a mathematical concept (a line which continually approaches a given curve but never meets it). In science there can be no apodictic certainty, i.e. there can be no final conclusive certainty beyond the reach of criticism.

Through the process of evolution the *Homo erectus* became the *Homo sapien* or the thinking man. He gave a condi-

tional gift of achieving the provisional truth. Lessing has wisely said, "If God held enclosed in his right hand the absolute truth and in his left hand simply the ever-moving impulse towards truth, although with the condition that I should eternally err and said to me 'choose', I would humbly bow before his left hand and say 'Father, give. Pure truth is for thee alone'." This difficult gift of God is invested with the precious element of the continuous thought process.

Rutherford, when approached by a student who wanted to do research work in nuclear physics, suggested, "Choose another field since work in this field has been completed." Future research was falsified and the nucleus that he discovered was smashed into smithereens. If Lessing had opted for the absolute truth, it would have spelt cognitive stagnation for the human mind.

The status of truth in respect of the work done by the scientist is offered to his peers either for verification or for falsification in the form of his submission in a scientific journal. This fact brings about the second facet of truth in respect of the scientist himself. The facts discovered by him in respect of a phenomenon carry the stamp of being amoral. However, when a scientist works to reach it, he must have the seal of absolute morality and faithfulness to the relevant methodology by which he has reached his scientific conclusions. This facet and the consequence of adherence to the mode of conduct is expressed by Dr J. Bronowski, one of the most eminent physicists. Dr Bronowski worked on the atomic bomb project and was deputed to Japan to observe the disastrous consequences of the bomb dropped on Hiroshima. After taking a look, he chose to discontinue research on the atomic bomb. He said, "The professional morality of scientists allows no compromises. It tells each man that he must report what he believes to be true, exactly and without suppression or editing. Nowhere in a research journal is a scientist allowed to minimise an awkward discrepancy or to stress a comforting confirmation." This not so common code of morality of communication stands supreme among the community of scientists. The American Scientific Association has made it mandatory to seek a pledge from the candidate that he loves truth for truth's sake and that he would endeavour to communicate the truth impartially.

A biographer of Nobel laureate S. Chandrasekhar began the first chapter of his biography by quoting the last words of the Nobel laureate, uttered during the award-giving ceremony speech:

The simple is the seal of the true,
And beauty is the splendour of truth.

Simplicity and splendour of truth are the hallmarks of scientific facts and the scientist.

Appendix-IV

Scientific Ideas and Ideals

Science today has accomplished the very basis on which it has taken its stand—that is, the study of nature. The parameters of such studies include learning to live with it, understanding it, controlling it and exploiting it. To achieve the last dimension of exploitation, controlled exploitation was resorted to. Science has succeeded on two fronts: liberating the mind from superstitions and liberating the muscles by technology. These advances in science are advances in concepts for clarifications of the phenomenon, with the limitations that have already been discussed in the preceding chapter on 'Science and Truth'. The values of such advancing ideas receive recognition through prestigious awards as the Nobel Prize. Scientific ideas are not value oriented. They carry a cognitive mark of an explanatory character for the matter under study. The second stage of some of these ideas is to transfer the conceptual character into an operational facility and thus the technological idea emerges. The difference between these two phases of scientific progress has been clearly stated by Edison. He invented numerous technological gadgets but missed one scientific idea. This scientific idea was exploited by Ambrose Fleming and applied to technological application which made Edison remark, "I am not a scientist. I am a technologist. Faraday is a scientist. I always work on the size of the dollar."

What is the difference between a scientific idea, a technological idea and an ideal? The first two are concepts where the first is a theoretical concept and the second, a pragmatic concept. When a scientific idea evolves into a technological idea and finds its operational aspect for human environment, it achieves the status of an ideal. A book on cricket gives the different types of ideas on the strokes that a batsman can

execute. However, when a 'little master' executes one such stroke on the ground, the crowd in the gallery shouts, "That's an ideal stroke!"

Scientific or technological ideas do not carry any value judgement. Otto Hahn's discovery of the fission of atom was evolved into a technological idea by Enrico Fermi as a chain reaction with a stupendous release of energy. This use of the release of energy led to the birth of the atom bomb or a reactor, where the use of the first spelt disaster and use of the second was a change of an idea into an ideal.

Appendix-V

Humour, Humility and Humanism in Science

Humour, humility and humanism are the three values which the scientist attempts to cultivate in his personal and social life despite the detached values of the scientific attitude with which he pursues his professional work. All three values, humour particularly, reflect an attitude and outlook of the scientist. Mahatma Gandhi had observed, "But for my sense of humour, I might have committed suicide." The same idea was expressed by the noted scientist W.Raabe when he said, "A sense of humour is the life-belt on the stream of life." Without going through the philosophical analysis of humour, one may classify humour by what it brings you—laughter, smile. Such a classification includes laughing at others, i.e. the mark of detachment and pride; laughing with others, i.e. the mark of happy association; and lastly, laughing at oneself, i.e. the mark of self-analysis. All these values are expressed in the work and the life style of a scientist. Take the instance of laughing at others. Galileo once wrote to Kepler in a letter: "Kepler, how I wish that we could have a hearty laugh together, principal professor of philosophy, whom I have repeatedly requested to look at the moon and planets through my glass but who pertinaciously refuses to do so."

The case of laughing with others is best expressed in the case of poems. In the heydays of the Cavendish laboratory, which was under J.J. Thomson and Rutherford, a meeting of scientists was organised and the proceedings printed under the title *Postprandial Proceedings of the Cavendish Society*. Certain lines of the poem recited at the function provide evidence of laughing together:

When the professor has solved a new riddle,
Or found a fresh fact, he's fit as a fiddle.

He goes to the tea-room and sits in the middle
And jokes about everything under the sun.
Then if you try to look grate at his jest,
You'll burst off the buttons which fasten your vest.
For when he starts chaffing,
Your tea you'd be quaffing,
You cannot help laughing
Along with the rest.

The last aspect of laughing at oneself points to the important value of humility in the scientist. Liebig, who missed discovering bromine, labelled his bottle wrongly as 'iodine chloride'. He then put that bottle in a cupboard and called it a 'cupboard of my mistakes'. Since then he resolved not to make any more theories till they could be directed and supported by unambiguous experiments. In another instance, Dr Alferd Castler, a Nobel laureate, once pointed out, "When a scientist looks at the development of science from within, the predominant feeling is not of pride but of humility, for each new triumph of science and each new principle discovered is what I might almost describe as a principle of recognition of limitations."

In the trinity of these values (humour, humility and humanism), the last one is perhaps the most important and forms part of the other two values too. Humanism in the process of definition gets crowded in semantic theories. However, Walter Lippmann says, "Humanism signifies the intention of men to concern themselves with the discovery of a good life on this planet by the use of human faculties." This definition has a personal facet while the terminal aspect of humanism is shown by one's concern for human beings. To further elaborate the two facets of humanism—personal and terminal—two instances are being cited.

Just after the last Great War, a General told Dr Albert Einstein with great pride that in the last war their casualties were relatively very small. At this Einstein asked, "General, relative to what?" This question by the proponent of the theory of relativity is similar to the argument put forth after the complete destruction of Hiroshima and Nagasaki with the atomic bomb, when it was argued that the bombing saved relatively the loss of manpower of the forces alive. In his argument Einstein posed the basic question on ethics: "Is ethics relative

to a situation or is ethics absolute as velocity of light?"

Einstein's reply shows that the ethic of humanism is not situation oriented but is an absolute action. This terminal value of humanism is represented in Dr Soltin's sacrifice of his own life to save the lives of his colleagues. Dr Soltin, involved with the atomic bomb project, was working with his seven colleagues in his laboratory on the scientific aspects of the radioactive element—plutonium. Suddenly the screw-driver slipped and the two pieces of plutonium, large enough to form a sufficient mass to start a chain reaction, filled the room with radioactivity. Dr Soltin, realising the danger to his colleagues, shouted to them to leave the laboratory, marked the place where they were standing, and then separated the two pieces of the radioactive material with his own hands. He knew that it meant an end of his life, but he also knew that his colleagues, due to his directions in pin-pointing their places, would be exposed to minimum dose of lethal radiation and be saved. The young Soltin died of exposure to radiation nine days later. J. Bronowski, in his tribute to Soltin's act of humanism and morality, said, "This is the highest morality—to combine human love with unflinching scientific judgement."

Appendix-VI

Role of Anecdotes in Value Education

Educational institutions are today facing the uphill task of implanting proper values during the process of knowledge education, at a time when the basic roots of individual morality can be seen lying stranded in a climate of moral uncertainty. According to the India Office records, Lord Wavell, in his farewell letter to the King, had written: "Education is the thing we have done worst in India, I believe, because we have provided education for the mind only and not the character. As a result, the average educated Indian has little character and no discipline. They will have to learn both if they are ever to become a nation."

This frank and self-critical observation of Lord Wavell holds true today too, even after more than four decades of it being made. When India achieved Independence, Prof. Laski made a very sarcastic remark to an Indian student, "Your Independence will lapse into a state of anarchy followed by tyranny and then swing back into great anarchy."

The student boldly replied, "It will be our tyranny and our anarchy."

This was indeed true but how ironical it was that the Indian student answered back so hopefully and not helplessly, possibly not realising what lay ahead for him and his companions.

Conceptual Approach to Value Education

The term 'values' may refer to interests, pleasures, likes, preferences, duties, moral obligations, desires, wants, needs, aversions, attractions, and many other modalities of selective ori-

entation. One of the most widely accepted definitions in social science is that values are concepts which are most desired and influence selective behaviour. Values serve as criteria for selection of action. When explicit and fully conceptualised, values become the criteria for judgement, preference, and choice; when implicit and unreflective, values nevertheless perform as if they constituted grounds for decision in behaviour. Human beings show preference for some things over others; they select one course of action rather than another out of a range of possibilities, and they do judge the conduct of other men.

The basic components may therefore be considered to be *firstly*, cognitive for reasoning out what is most desirable from all that is desired; *secondly*, connative to determine a behavioural pattern—be it of utility or pragmatic; and *thirdly*, affective so as to influence the action on the basis of emotions and feelings.

A value (or belief) about the desirable, therefore, involves some knowledge about the means or ends considered to be desirable; some degree of effect or feeling, because values are not neutral but influenced by personal feelings and generate effect when challenged; and the behavioural component, when a value that is activated may lead to action.

Values referring to modes of conduct are called *instrumental values* and encompass concepts of honesty, love, responsibility and courage. Values referring to end-states of existence are called *terminal values*, and include such concepts as freedom, equality, a world at peace, and inner harmony.

Operational Approach to Value Education

As to how the values can be activated invariably leads to a clash of views in respect of desirability of such an approach. The prime function of any educational institution should be to inculcate values in the students, though some people believe that values must not be taught but caught, and hence the whole environmental profile of the institute must achieve this objective. It is therefore pertinent to find a golden mean between 'taught' and the 'not taught but caught' by devising the totality of instructional/non-instructional approach for implanting the values. Jacob W. Getzels, in his article on 'Schools and

Values' (*Centre Magazine*, May-June 1976), finds that the contemporary youngsters, due to lack of visible and consistent models for identification, find themselves in a situation that creates difficulties in social adaptation. He contends that it is not sufficient to teach values or to clarify values; teachers and other adults must also act as models with whom the young can identify. Educators often lecture students about the importance of acquisition of 'appropriate' values without demonstrating through their own actions what those values are.

The modes of learning values have been classified in four categories. There are four E's for implanting values in the general process of teaching: exhortation, example, expectation and experience.

- *Exhortation* : Telling what is right and what is wrong; to live by certain sets of standards.
- *Example* : Moral model in an environment; learning depends on the learner's feelings towards the model.
- *Expectation* : Confirming the expectations to a classroom environment.
- *Experience* : Act of involvement in certain experiences.

The moral educational movement supporting the four E's further mentions some steps for implementation of value education. *Firstly*, such a value behaviour must be chosen freely; *secondly*, the chosen value must fall into a behavioural pattern different to value-oriented alternatives; *thirdly*, the chosen value must not be felt as imposed upon but cherished privately; *fourthly*, the chosen value as a behavioural pattern must have public acknowledgment; and *lastly*, such value-oriented behavioural pattern must not be an occasional instance but a permanent feature of one's character.

Classification and Role of Anecdotes in Value Education

The two-fold analysis of value education—conceptual and operational approach—must be examined with reference to the role that anecdotes play (general/scientific) to achieve value orientation in the teaching process of different disciplines. Short stories can easily be classified as fables, parables and anecdotes. A fable has been defined as a story not founded on fact, but has generally animals as characters and carries a moral.

Aesop developed it superbly into *Aesop's Fables*. Aesop being a slave took animals as his characters for moral education so as not to insult his Greek elitist masters. A parable has been defined as a narration of imagined events—allegory used to typify moral or spiritual relations. This valuable attention-catching technique was used very successfully by Jesus Christ and Ramakrishna Paramhansa in their public sermons. The third type of short stories—anecdotes—has been defined as the narration of a detached incident or a single event, told as being in itself interesting or striking. The distinction between the first two (fable, parable) and the third (anecdote) is that the first category is in the imaginary field while the second is based on reality.

Anecdotes, being narrations of various personalities during different fields of activities, invariably have something new to tell. The Oxford University Press has published literary anecdotes both of English and American personalities. Then there are legal anecdotes, anecdotes of theatre, while we offer anecdotes of scientists. The linking of such anecdotes for value education has a two-fold approach: during a lecture, while developing a specific discipline the anecdotes must be linked to the field; and since the anecdote of specific discipline does not rely on the discipline which is being pursued but on the character of that person, it can be used to elucidate a point in value education.

The profession of the scientist entails *firstly*, teaching his discipline while conducting research in his discipline, reading and learning for expanding his sphere of knowledge and at times, cutting across boundaries of other disciplines to create inter-disciplinary subjects. *Secondly*, attending to his personal and social life. The values needed for the first aspect, especially with reference to research, are pursued with a scientific attitude which involves analytical observation of his problem along with the objective of his work viewed with a detached mind. All these are cool objectives devoid of purpose, while the second facet of his personal life—'detached attitude'—must be avoided. In both facets, the cluster of values may be summed up as morality of training and commitment. The morality of commitment may be exhibited in the surgical performance of Lord Moyniham, the great British surgeon. Lord

Moyniham had just finished operating before a gallery full of distinguished visiting doctors, when he turned to them and said, "You see, there are just three persons present in the operating room when I operate—the patient and myself."

"But that is only two," his questioner commented. "Who is the third?"

Moyniham responded, "The third is God."

On the other hand, Dr Richard Feynman, Nobel laureate in physics, was an excellent teacher of physics. BBC in their programme 'Horizon' arranged for his participation. A Mrs Marcus Chown, the mother of a graduate student of Dr Feynman, who never listened to science programmes was induced by her son to listen to this transmission. She was so thrilled by it that she sat right through the programme. The son, who knew his mother's aversion to scientific subjects, decided that if his guide were to write a personal letter to his mother, her interest in science would be sustained. Dr Feynman, to please his student, wrote the following letter to his mother, "Dear Mrs Chown, ignore your son's attempts to teach you physics. Physics is not the most important thing; love is! Best wishes, Richard Feynman."

While Lord Moyniham represents the pursuit of his profession with devotional commitment, Nobel laureate Feynman throws light on the value of love in professional work. These two anecdotes bring out the value orientation both in professional work and personal life of a scientist.

The present day stress on curriculum content has brought about complete neglect of value education. T.S. Eliot has said, "Where is wisdom that is lost in knowledge and where is knowledge that is lost in information?" This observation of the poet holds particularly true now with the emergence of sophisticated computers. Had Eliot been alive, he would have asked, "Where is the computerised information that offers relevant knowledge and where is the relevant knowledge that ought to be sublimated in wisdom?"

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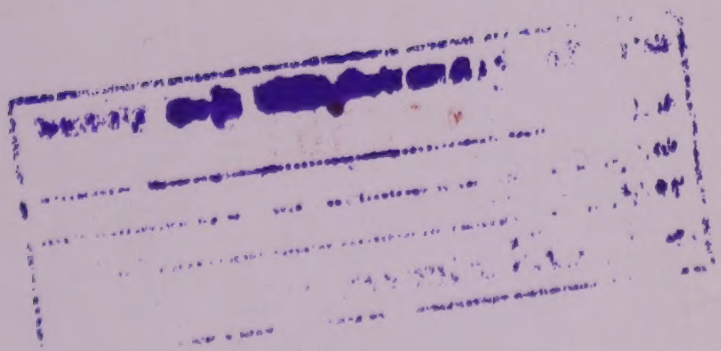

Although abundance of material is available in the form of biographies and writings of scientists, very little information is found on what made these scientists not only great discoverers but humane too, blessed with humour, humility and humanism like us, the lesser known mortals. Science is in a continuous state of progression and those involved in this unique adventure bring out the modes and methods of their investigation. The basic discoveries of scientific investigation have been discussed in different essays in this book with the hope that the layman may achieve 'scientific literacy', even if it is in a small measure.

A. N. Kothare, born in 1906, taught both physics and chemistry for more than six decades at the University of Bombay. He received the 1968 Gold Medal from Paul VI and the Outstanding Teacher Award of 1971 from the government of Maharashtra. He died while this book was under print.

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